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INVESTIGATIONS OF THE RELATIONSHIP BETWEEN LAND USE, RAINFALL, AND RUNOFF QUALITY IN THE TAYLOR CREEK WATERSHED

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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INVESTIGATIONS OF THE RELATIONSHIP BETWEEN LAND USE, RAINFALL, AND RUNOFF QUALITY IN THE TAYLOR CREEK WATERSHED

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WEST PALM BEACH, FLORIDA

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ACKNOWLEDGEMENTS

The design and implementation of this study was carried out under the direction of David Hallett (formerly with the South Florida Water Management District) and Larry Grosser. Field work and sample collection was ably performed by Larry Grosser and Tom Raishe.

ABSTRACT

Water chemistry was examined in four sub-basins of the Taylor Creek watershed: Mosquito Creek, Williamson East Lateral, Otter Creek, and NW Taylor Creek. Diurnal samples were collected at six hour intervals for three consecutive days at the discharge point of each sub-basin four times during the period July to September 1975. A total of eleven chemical parameters were measured on each sample in the laboratory including nutrient forms and major ions.

Results indicate that surface waters in Otter Creek and Mosquito Creek contain very high levels of total nitrogen (6.97 and 2.88 mg N/l) and total phosphorus (2.97 and 2.09 mg P/l). Surface waters in Williamson East Lateral contain extremely high chloride levels (330.1 mg/l).

Land use patterns were shown to influence the water quality in each sub-basin. Specifically, dairy farm operations appeared to be significant sources of nitrogen and phosphorus, improved pastures appeared to be significant sources of nitrate, citrus groves appeared to be significant sources of sodium and chloride, and marshes and/or cropland appeared to be significant sources of potassium and silica.

An "ad hoc" rainfall factor was developed in order to examine the effects of rainfall. Based on this factor rainfall appeared to affect total nutrient levels, nutrient speciation (except for NO_2^- and NO_3^-), and ionic composition in the four sub-basins. The rainfall factor also appeared to account for some of the temporal variation in phosphorus.

INTRODUCTION

Nonpoint source pollution is a major problem in Florida, especially in relation to the eutrophication of lakes and waterways. Frequently the importance of diffuse nutrient sources exceed point sources in terms of the total nutrient load to a body of water (Ashton and Underwood 1975). Nutrient runoff from agricultural watersheds is often considered to be a non-point source of pollution. However, the relatively flat topography, sandy soils, and high water table conditions found in South Florida usually restricts overland sheet flow. Drainage, therefore, is usually provided via extensive ditch networks which discharge into increasingly larger water conveyance canals. Diffuse pollution first entering these drainage channels can be considered as being non-point in origin. After entering the extensive water management systems, the diffuse runoff is channelized and the distinction between point and non-point source becomes obscured especially with respect to receiving bodies. Channelized runoff, however, remains a major pollution problem in Flórida. In addition to nutrient releases from this type of pastureland and cropland runoff, there are significant nutrient loads associated with confined dairy and feedlot operations. Mass loadings from these latter sources and from artesian irrigation can be considered to be more point source in origin. In order to adequately define the problems caused by these types of pollution and help develop suitable pollution abatement techniques, there must be an increased understanding of the relationship between causal mechanisms and environmental factors. The objectives of this study, therefore, were threefold:

1. Document the runoff water quality in four sub-basins in the Taylor Creek watershed which have different land use patterns.

2. Determine if different land use patterns affect the quality of runoff as measured by nitrogen, phosphorus, and major ions.

3. Determine if there is a temporal effect on the quality of runoff.

I. Description of Study Area

The Taylor Creek watershed covers approximately 332 km^2 (128 mi^2) of Okeechobee County, Florida and is drained by Taylor and Mosquito Creeks (Fig. 1). Headwater flow to Taylor Creek is provided by four tributary branches: the main channel which drains the north central portion of the basin; an unnamed tributary which drains the northwest area; and Little Bimini and Otter Creek which drain the northeastern areas. The other major tributary to Taylor Creek is Williamson Ditch which was privately constructed in 1945. Historically the combined flow of Taylor Creek and Williamson Ditch emptied into Lake Okeechobee near the city of Okeechobee. In 1973, for water management purposes, the discharges of the Taylor Creek and Nubbin Slough drainage basins were combined. The majority of the flow from Taylor Creek is presently diverted via a control structure (S-192) and canal (L-63N) to Nubbin Slough where the combined flow of the two water courses discharge into Lake Okeechobee through structure S-191.

The Taylor Creek basin lies within the physiographic regime of the Okeechobee Plain (Puri and Vernon 1964) with altitudes ranging from 70 ft. MSL in the north to 20 ft. MSL on the northeast shore of Lake Okeechobee. Soil within the basin is dominated by the Myakka-Basinger Association which is characterized by broad, sandy lowlands with very strongly acid gray sands underlain by a brown organic stained pan 42 inches from the surface. The groundwater table normally fluctuates 42 inches below the surface. Land use within the Taylor Creek watershed is dominated by agriculture including improved pasture, dairy operations, and to a lesser extent cropland and

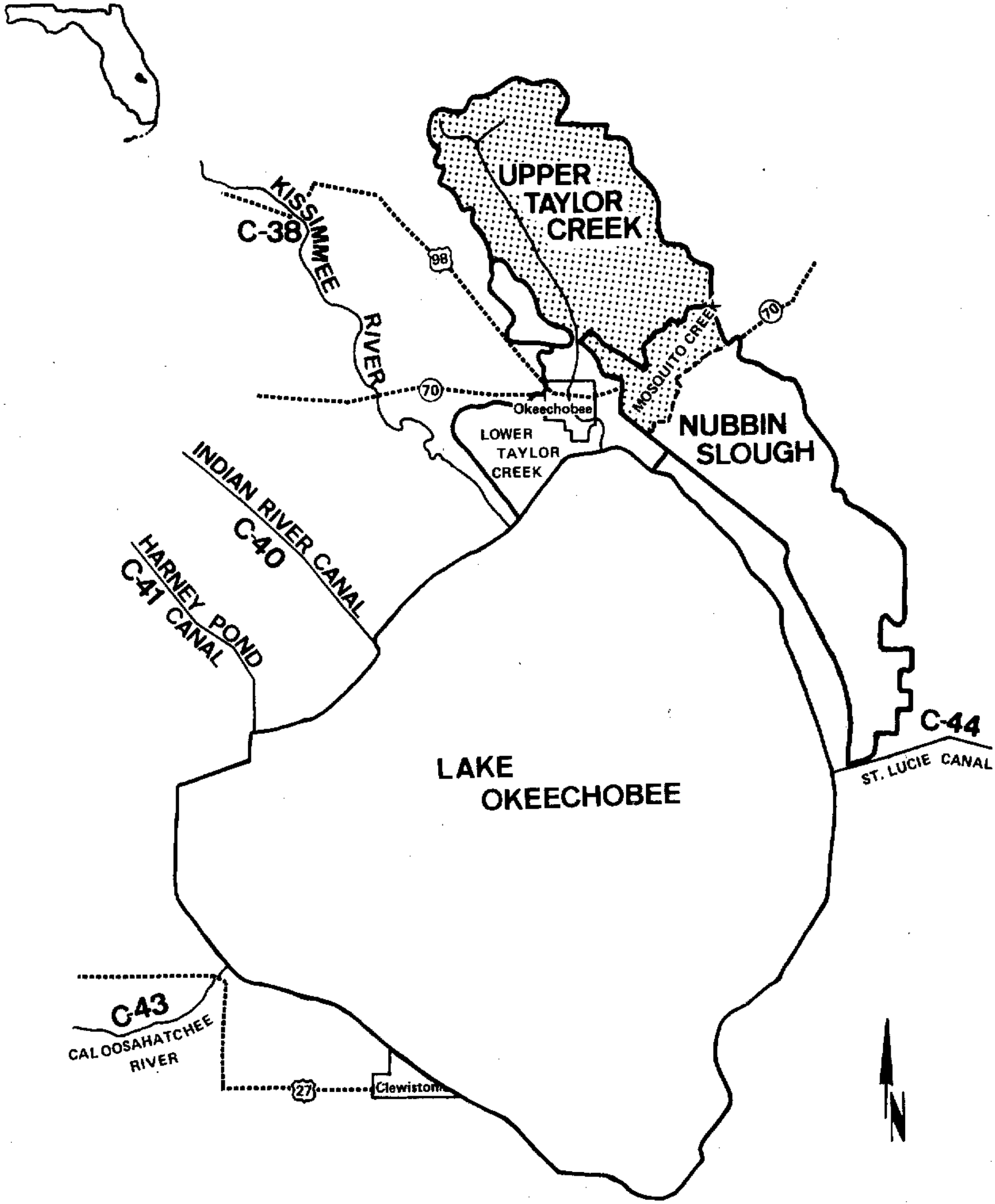

FIGURE 1. LOCATION MAP OF THE TAYLOR CREEK BASIN

citrus. Urban areas are restricted to a portion of the city of Okeechobee near the mouth of Taylor Creek and widely scattered farm houses which are usually associated with dairy operations.

The water quality study described in this report concentrated on four areas of Taylor and Mosquito Creeks (Figure 2): (1) Upper Mosquito Creek, (2) Williamson Ditch (East Lateral), (3) Otter Creek, and (4) Upper NW Taylor Creek. Land use characteristics for each sampling area are presented in Table 1.

In terms of land use, Upper Mosquito Creek is devoted almost entirely to improved pasture cattle operations (93.5 percent). Within this sub-basin are three major dairy operations (Table 2) which contain approximately 4,530 milking cows. The actual dairy buildings and associated labor housing covers approximately 8.7 percent of the total land area (9.3 percent of the total pasture areas). A small portion of the basin remains as freshwater swamp (6.5 percent).

Land use in the Williamson Ditch East Lateral sub-basin is also dominated by improved pasture (79.7 percent), but contains no intensive dairy operations. A distinctive feature of this basin is that approximately 6.3 percent of the area is covered by citrus orchards which require extensive drainage and irrigation. Irrigation is provided by saline ($\sim$1840 mg/l as Cl) artesian well water.

To the degree of accuracy inherent in measuring land use areas, the Otter Creek sub-basin is devoted entirely to cattle operations which maintain approximately 6,909 cows. The six intensive dairy operations (Table 2) within the watershed manage about 4,550 milking cows. The buildings and associated labor housing connected with the dairies cover over 21 percent of the watershed.

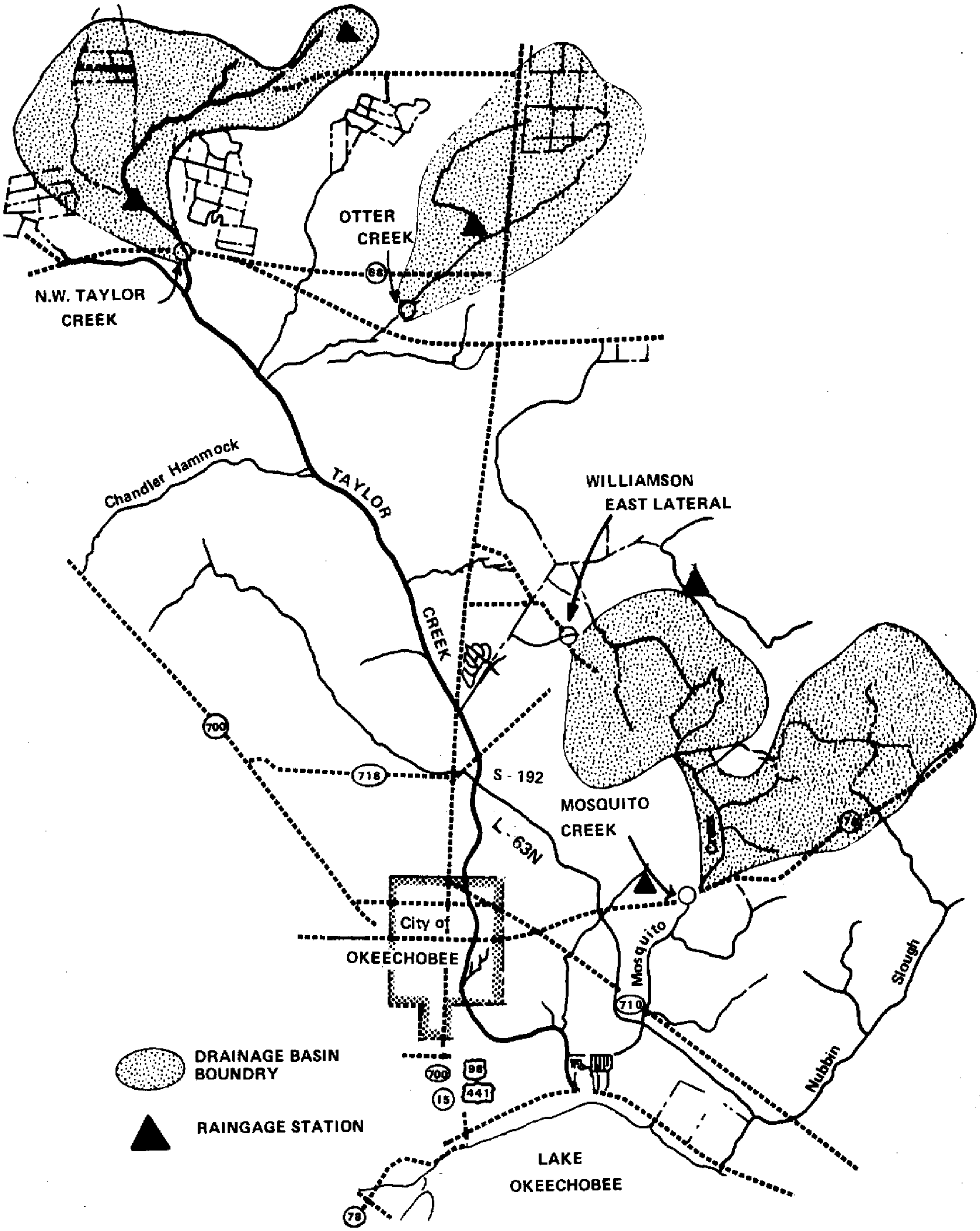

FIGURE 2. LOCATION OF SAMPLING SITES, RAIN GAGES, AND BASIN BOUNDARIES

TABLE 1. LAND USE PATTERNS FOR UPPER TAYLOR CREEK AND MOSQUITO CREEK

1972 Land Use (km^2)

Station	Freshwater Swamp	Freshwater Marsh	Cropland	Citrus	Improved Pasture	Dairy Operations	Sum Total
Mosquito Creek	1.55 (6.5%)	-	-	-	20.2 (84.8%)	2.07 (8.7%)	23.83
Williamson East Lateral	2.33 (14.1%)	-	-	1.04 (6.3%)	13.21 (79.6%)	-	16.58
Otter Creek	-	-	-	-	17.09 (78.6%)	4.66 (21.4%)	21.75
NW Taylor Creek	1.33 (5.3%)	1.04 (4.2%)	1.04 (4.2%)	- -	21.5 (86.4%)	-	24.86

Source: Interpretation from 1972 Mark Hurd aerial surveys and USGS quadrangle maps.

Scale: Okeechobee County General Highway Map (1:126,720)

TABLE 2. LOCATION OF DAIRIES AND APPROXIMATE NUMBERS OF COWS IN SUB-BASINS OF MOSQUITO AND OTTER CREEKS.

Sub-Basin	Dairy	Location	No. Heifers	No. Milking Cows	No. Dry Cows	Total Cows
Mosquito Creek	#1	Mosquito Creek, Sec. 8, T37S; R36E	0	1,515	458	1,973
	#2	Mosquito Creek, Sec. 7, T37S; R36E	0	1,494	435	1,929
	#3	Mosquito Creek, Sec. 5, T37S; R36E	0	1,523	503	2,026
		TOTAL:	0	4,532	1,396	5,928
Otter Creek	#4	Otter Creek, Sec. 27, T35S; R35E	700	420	155	1,275
	#5	Otter Creek, Sec. 22, T35S; R35E	0	580	95	675
	#6	Otter Creek, Sec. 22, T35S; R35E	160	550	234	944
	#7	Otter Creek, Sec. 22, T35S; R35E	0	1,032	347	1,379
	#8	Otter Creek, Sec. 14, T35S R35E	0	1,028	301	1,329
	#9	Otter Creek Sec. 11, T35S; R35E	0	947	360	1,307
		TOTAL:	860	4,557	1,492	6,909

Source: McCaffery et al. 1976, modified by personal communication with Kent Price (Okeechobee County Agricultural Agent)

The Upper NW Taylor Creek area is more diversified than the other three basins in that it contains four different land uses. Freshwater swamp and marsh accounts for approximately 9.5 percent of the area while an additional 4.2 percent is covered by cropland. However, in similar fashion to the other three sub-basins, the Upper NW Taylor Creek watershed is dominated by improved pasture (86.5 percent). As in the case of the Williamson Ditch East Lateral area, the unimproved pasture does not support any intensive dairy operations.

II. Sampling and Analytical Methods

Chemical Methodology and Sampling Frequency

Four water quality stations were established in the Taylor and Mosquito Creek drainage basins (Figure 2): (1) Mosquito Creek (at Highway 70); (2) Williamson East Lateral; (3) Otter Creek (at Otter Road bridge); and (4) NW Taylor Creek (at Highway 68). These stations were sampled four times (in July, August, and September) during the 1975 wet season (Table 3).

The sampling regime consisted of collecting diel samples every six hours over the course of three days. Surface water samples were collected by ISCO(R) Model 1391 automatic samplers every three hours and combined into six hour composite samples. Dissolved nutrient and major ion samples were preserved by filtration through 0.45 micron Nuclepore membrane filters. Unfiltered samples were collected for total nutrient analysis. All samples were stored in polyethylene bottles. In the laboratory samples were stored in the dark at 4° C. Laboratory analysis of samples were completed within one to two weeks after collection.

Eleven chemical parameters were determined on each sample as follows:

a. Nutrient forms: nitrate, nitrite, ammonia, total Kjeldahl nitrogen, ortho-phosphate, total phosphate, and silica.

TABLE 3. TEMPORAL DISTRIBUTION OF SAMPLING REGIME

	Number of Samples Taken at Station			
Date	Mosquito Creek	Williamson East Lateral	Otter Creek	NW Taylor Creek
7/8/75	2 *	2	2	2
7/9	4	4	4	4
7/10	4	4	4	4
7/11	2	2	2	2
7/31	2	2	2	2
8/1	4	4	4	4
8/2	1	4	4	4
8/3	0	2	2	2
8/19	2	2	2	1
8/20	4	4	4	1
8/21	4	3	4	0
8/22	2	0	2	1
9/24	2	2	2	2
9/25	4	4	4	4
9/26	4	4	4	4
9/27	2	2	2	2
TOTAL	43	45	48	39

* Multiple daily samples were collected at six hour intervals

b. Major ions: sodium, potassium, chloride, and alkalinity.

Chemical analyses were performed using methods that were either recommended or approved by the American Public Health Association or the Environmental Protection Agency. Most analyses were either performed on a Technicon Industrial Systems II AutoAnalyzer or a Perkin Elmer Model 306 Atomic Absorption Spectrophotometer. Complete description of specific methodologies are presented in Appendix A.

Land Use Methodology

Drainage basin boundaries for each station were estimated using the five foot surface contours on United States Geological Survey Quadrangle maps (scale: 1: 24,000). Only channels that were indicated on the quadrangle maps were considered in delineating the boundaries. Boundary lines were transcribed to an Okeechobee County General Highway map (scale 1: 126,720) (Figure 2). Land use types, derived from 1972 Mark Hurd Aerial Surveys (scale 1: 24,000) by the Land Resources Division of the South Florida Water Management District were transcribed to a transparent overlay (scale 1: 126,720) and placed over the boundary line map. For purposes of this report the following land use categories were defined.

1. Freshwater swamp: forested wetlands
2. Freshwater marsh: non-forested wetlands
3. Cropland: all agricultural land excluding citrus and pastureland
4. Citrus: all types of citrus orchards
5. Improved pasture: native land which has been noticeably improved (i.e., irrigated, ditched, burned, seeded, fertilized). Excludes areas devoted to cropland, citrus orchards and buildings associated with any agricultural operation.
6. Dairy operations: Those buildings associated with intensive

dairy operations. This includes the associated labor housing, but does not include the surrounding improved pastureland.

Land use areas were planimetered using a Keuffel and Esser Model 4236 planimeter.

Statistical Methodology

Four statistical techniques were employed in order to investigate the relationships between land use, rainfall, and runoff water quality: analysis of variance, multivariate analysis of variance, Duncan's multiple range test and principal component analysis. Detailed discussion of the theoretical aspects and assumptions of these techniques can be found in Steel and Torrie (1960), Cochran and Cox (1957), and Morrison (1976). The Biomedical Computer Programs (Dixon 1974) were used for multivariate analysis of variance (BMD 11V) and principal component analysis (BMD 01M) while the Statistical Package for the Social Sciences (Nie *et al*. 1975) was used for the other statistical analyses. All these computer programs were executed at the Florida State University Computing Center, Tallahassee, Florida.

III. Water Quality Characteristics of Stations

Mosquito Creek

Considering biogenic parameters, the water quality at Mosquito Creek is presently in a degraded state. Total N ranged from 1.33 to 5.45 mg/l with a mean of 2.88 mg/l for the four sampling periods. Nitrogen speciation was primarily restricted to organic N and ammonia which represented approximately 61 and 38 percent, respectively, of the total N present (Table 4). The majority of the variation in total N can be attributed to ammonia fluctuations, although no consistent diel trends were observed (Figures 3 to 6). Total P values were also high, averaging 2.09 mg P/l

TABLE 4. SUMMARY OF SELECTED WATER CHEMISTRY PARAMETERS FOR TAYLOR CREEK

Parameter (mg/l)	Station: Mosquito Creek	Williamson E. Lat.	Otter Creek	N.W. Taylor Creek
NO_2^--N	0.011 (1) 0.005 (2) 0.007-0.030 (3)	0.016 0.007 0.004-0.033	0.233 0.378 0.009-1.56	0.013 0.005 0.004-0.021
NO_3^--N	0.043 0.073 0.004-0.311	0.050 0.066 0.007-0.345	0.216 0.312 0.004-1.88	0.074 0.077 0.004-0.380
NH_4-N	1.08 1.00 0.02-4.16	0.15 0.009 0.01-0.38	3.53 1.30 1.10-6.39	0.05 0.03 0.01-0.12
TKN	2.83 1.12 1.30-5.39	1.54 0.16 1.17-1.93	6.52 1.84 2.36-11.2	1.81 0.31 1.33-2.75
Ortho-P	1.92 0.46 1.20-2.74	0.37 0.14 0.223-0.823	2.16 0.48 1.34-3.27	0.297 0.144 0.138-0.644
Total-P	2.09 0.50 1.26-2.90	0.436 0.16 0.267-0.905	2.97 0.78 2.01-6.21	0.453 0.174 0.238-0.957
Na	30.0 5.5 22.0-40.8	165.8 68.7 41.0-282.1	40.4 22.6 22.6-100.1	11.7 3.0 5.83-15.6
K	8.9 2.2 5.0-14.0	6.79 1.14 3.81-8.49	14.3 2.9 9.17-29.0	2.5 0.66 1.30-4.08
Cl^-	53.2 7.2 42.3-64.6	330.1 162.5 37.3-579.8	75.9 49.3 39.8-203.9	23.6 7.3 15.7-63.7
SiO_2	9.9 0.9 8.6-11.9	9.0 0.6 7.3-9.9	9.9 1.1 7.3-11.7	6.4 1.5 4.6-9.7
Alkalinity (as $CaCO_3$)	91.5 2.4 87.5-94.5	59.8 28.0 4.9-85.0	68.9 4.6 63.0-74.0	- - -

(1) time weighted average
(2) standard deviation
(3) range over all sampling dates

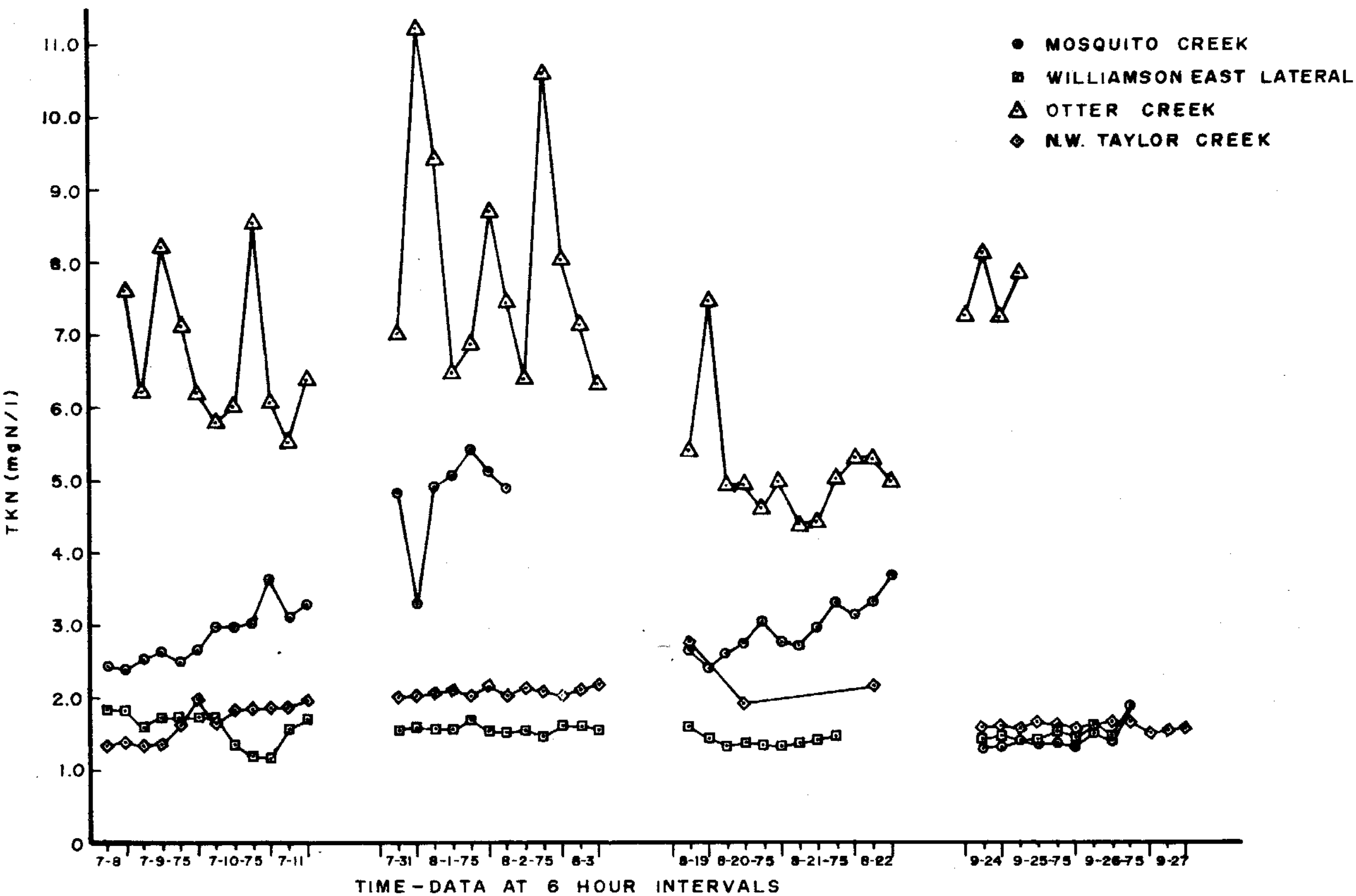

Figure 3 TKN CONCENTRATIONS AS A FUNCTION OF TIME

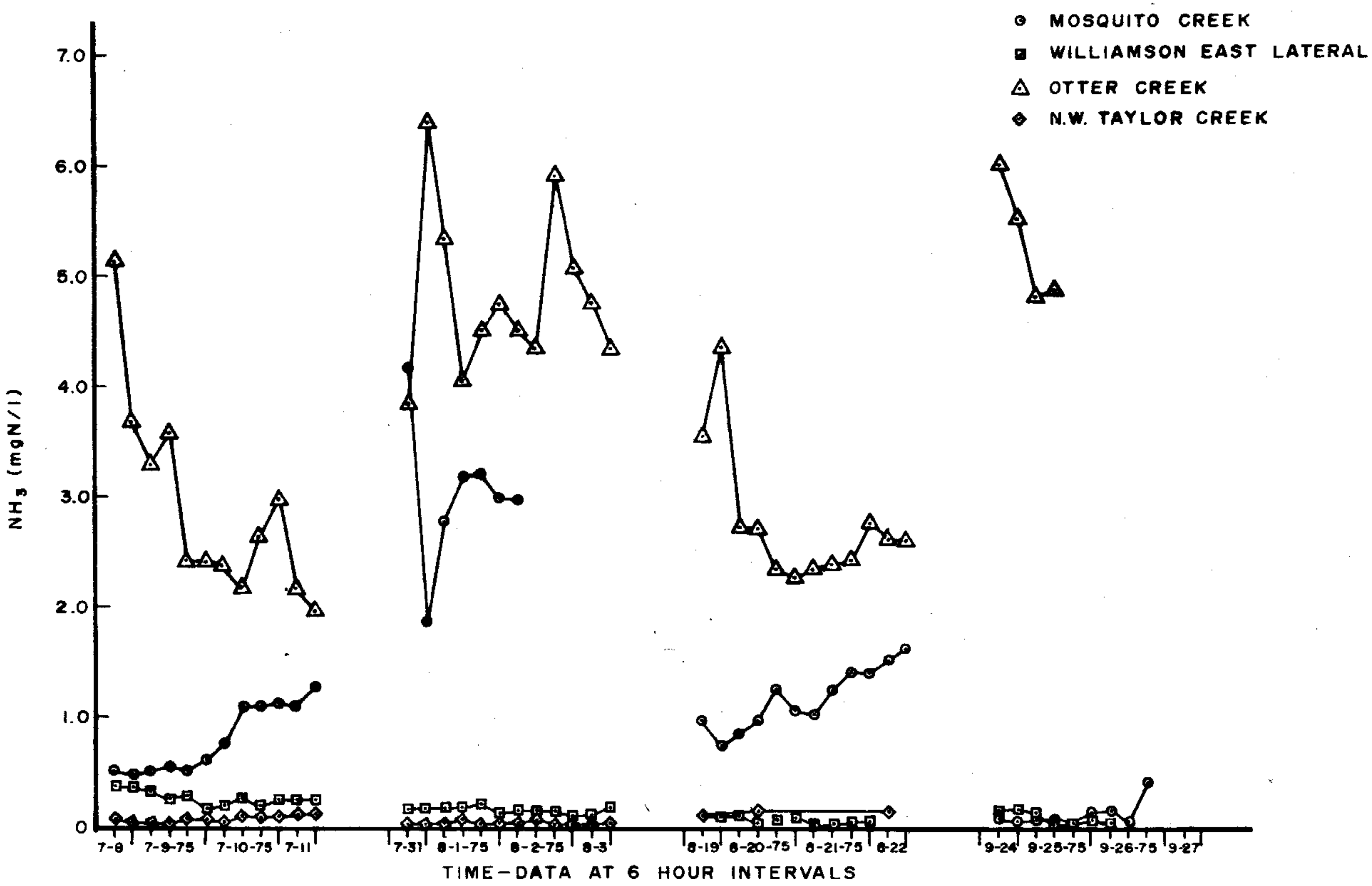

Figure 4 AMMONIA CONCENTRATIONS AS A FUNCTION OF TIME

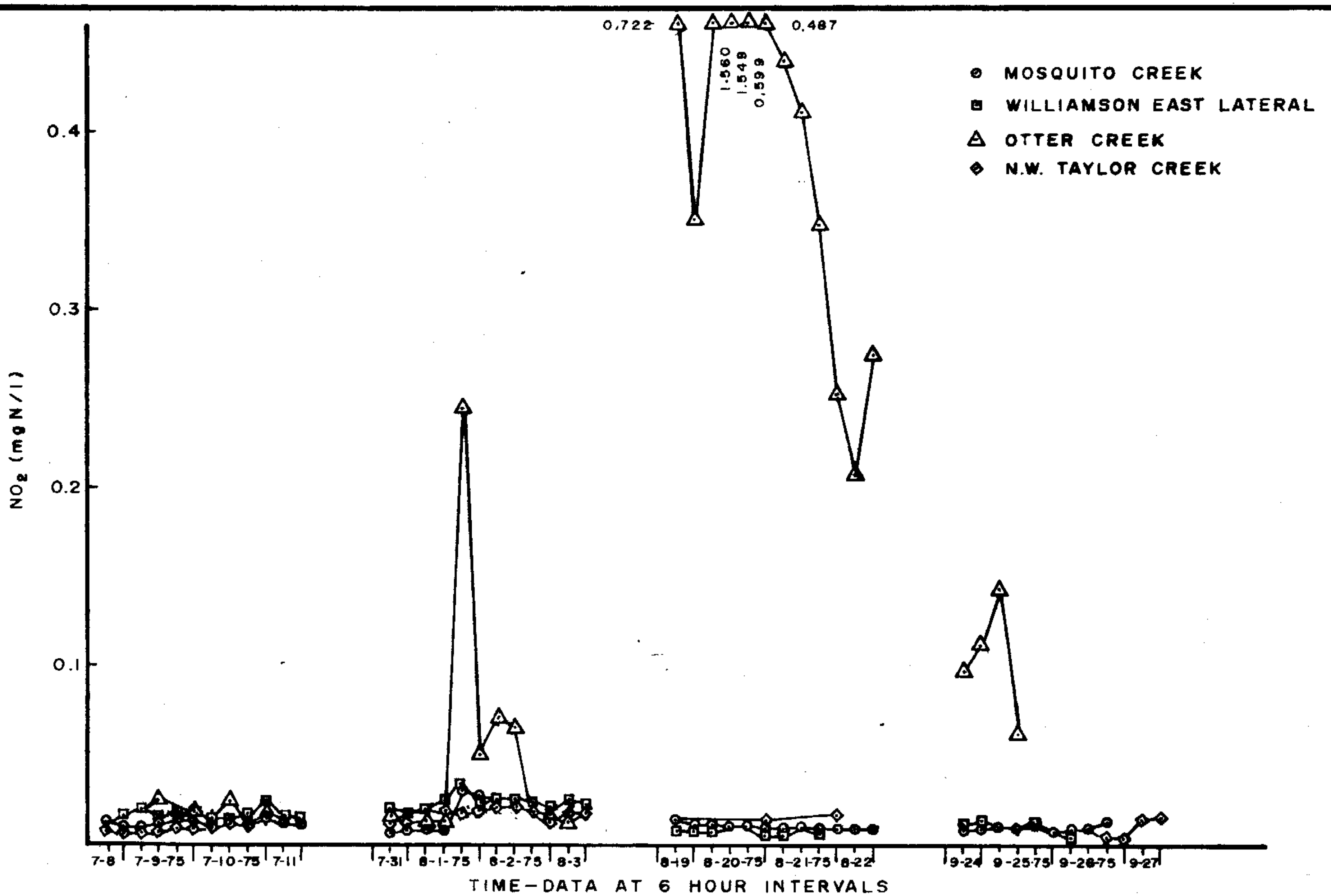

Figure 5 NITRITE CONCENTRATIONS AS A FUNCTION OF TIME

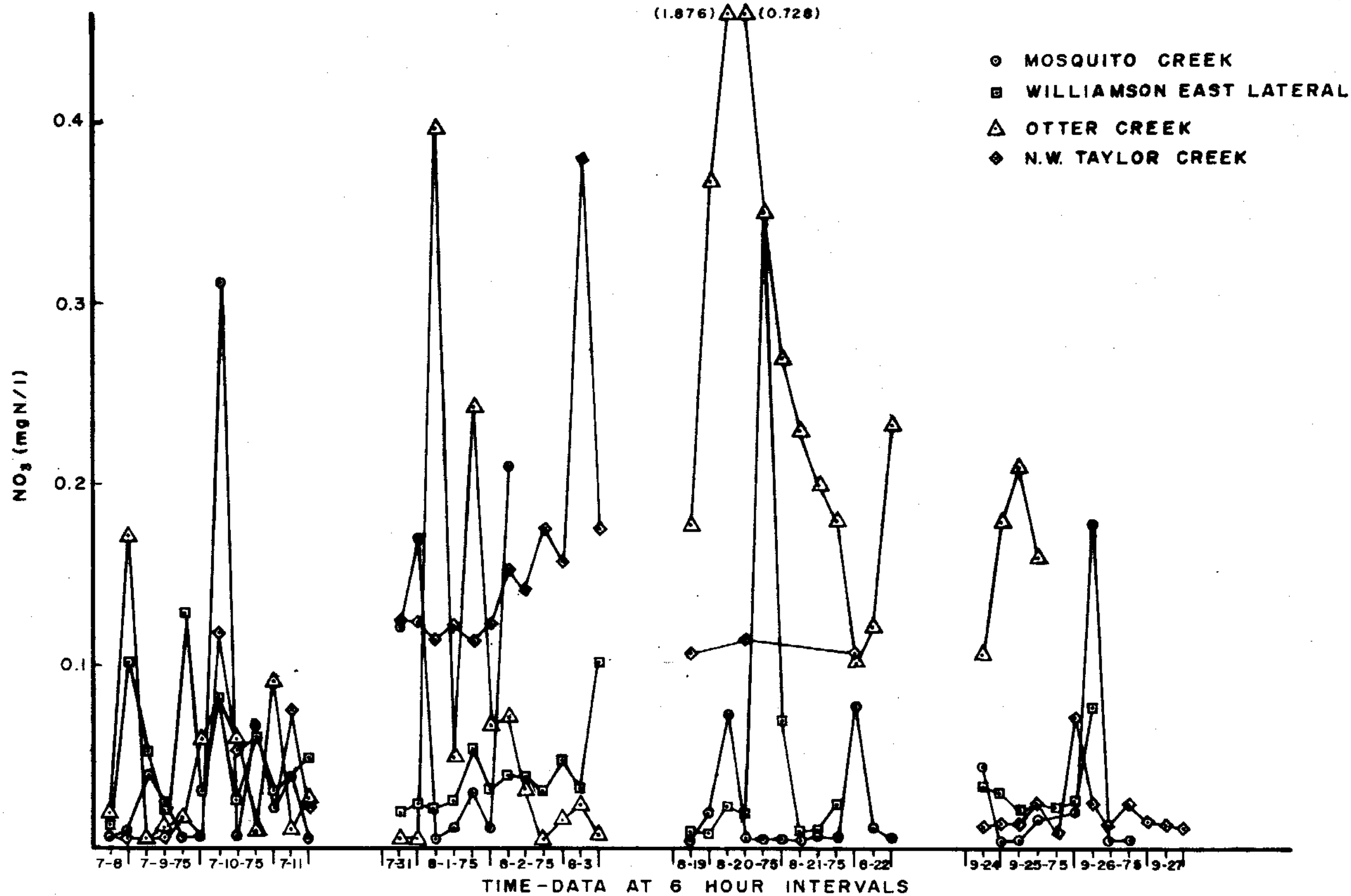

Figure 6 NITRATE CONCENTRATIONS AS A FUNCTION OF TIME

of which 1.92 mg P/l (92 percent) was in the ortho P form. The variability in total P was approximately half that of nitrogen. The high concentrations of ammonia and ortho-P found at this site could rapidly adversely impact receiving waters since they are readily assimilable inorganic species. The high levels of organic nitrogen present could have a delayed impact on receiving waters. In addition the mean inorganic N to ortho-P ratio of 0.59 suggests a large overabundance of phosphorus relative to aquatic plant needs.

In terms of general water chemistry, Mosquito Creek can be characterized as being relatively high in chlorides (53.2 mg/l) and moderately high in sodium (30.0 mg/l), potassium (8.9 mg/l), and alkalinity (91.5 mg/l as $CaCO_3$).

Williamson East Lateral

Williamson East Lateral represents the best water quality found in this study. Total N and P levels remained relatively constant at comparatively low mean levels of 1.61 and 0.44 mg/l, respectively. Organic N and ortho-P were the dominant nutrient species present, with each accounting for approximately 85 percent of their respective total nutrient levels. No consistent diel patterns were readily observable for any of the nutrient forms (Figures 3 to 8). The mean inorganic N to organic-P ratio of 3.7 at this station is more in balance with aquatic plant needs than the ratio calculated for Mosquito Creek.

The extremely high chloride (330.1 mg/l) and sodium (165.8 mg/l) levels found at Williamson East Lateral reflect the possible impact of deep groundwater irrigation in this sub-basin.

Otter Creek

Otter Creek reflects the poorest water quality of any station sampled in this study. Total N and P concentrations reached a maximum of 11.19

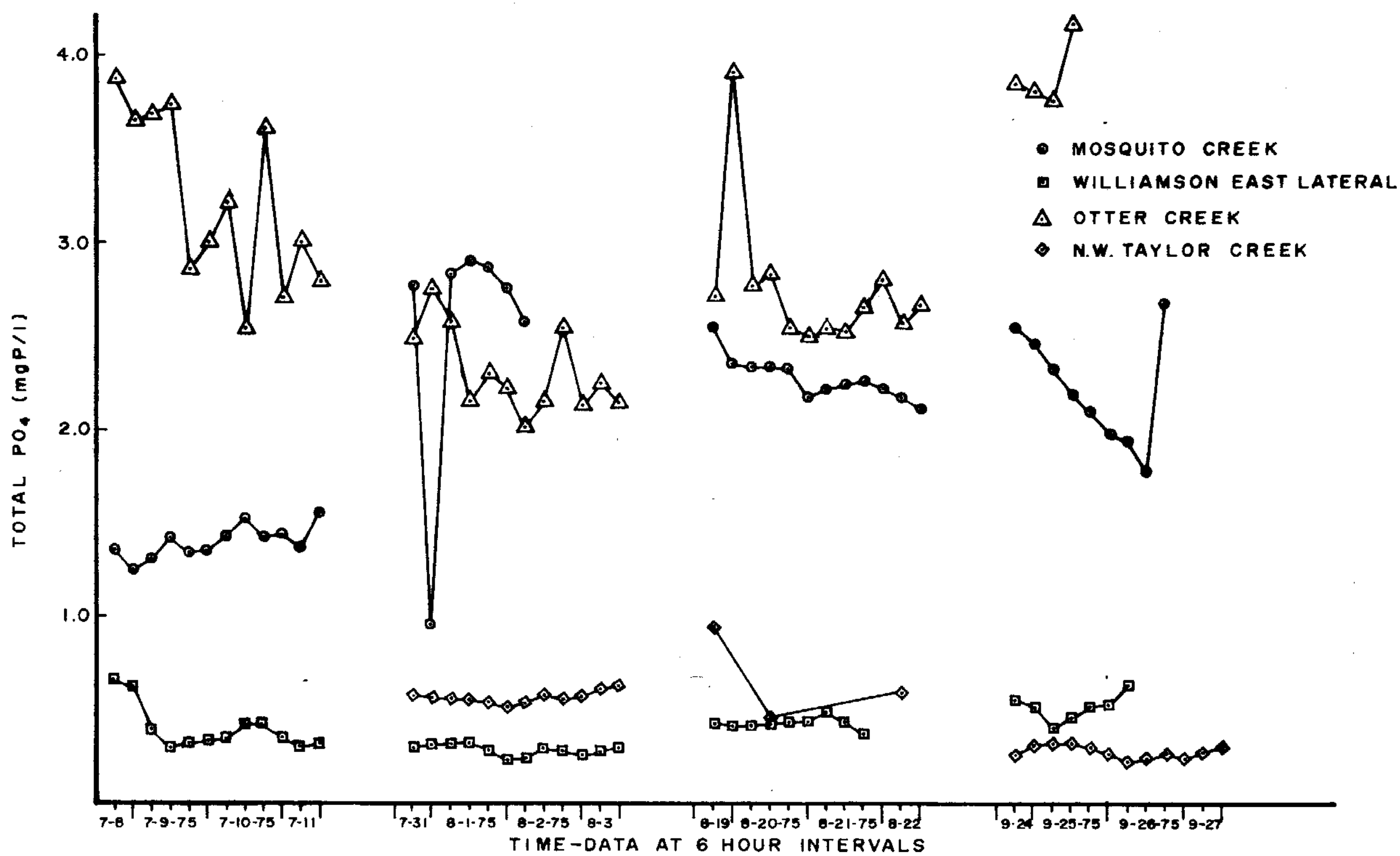

Figure 7 TOTAL PHOSPHORUS CONCENTRATIONS AS A FUNCTION OF TIME

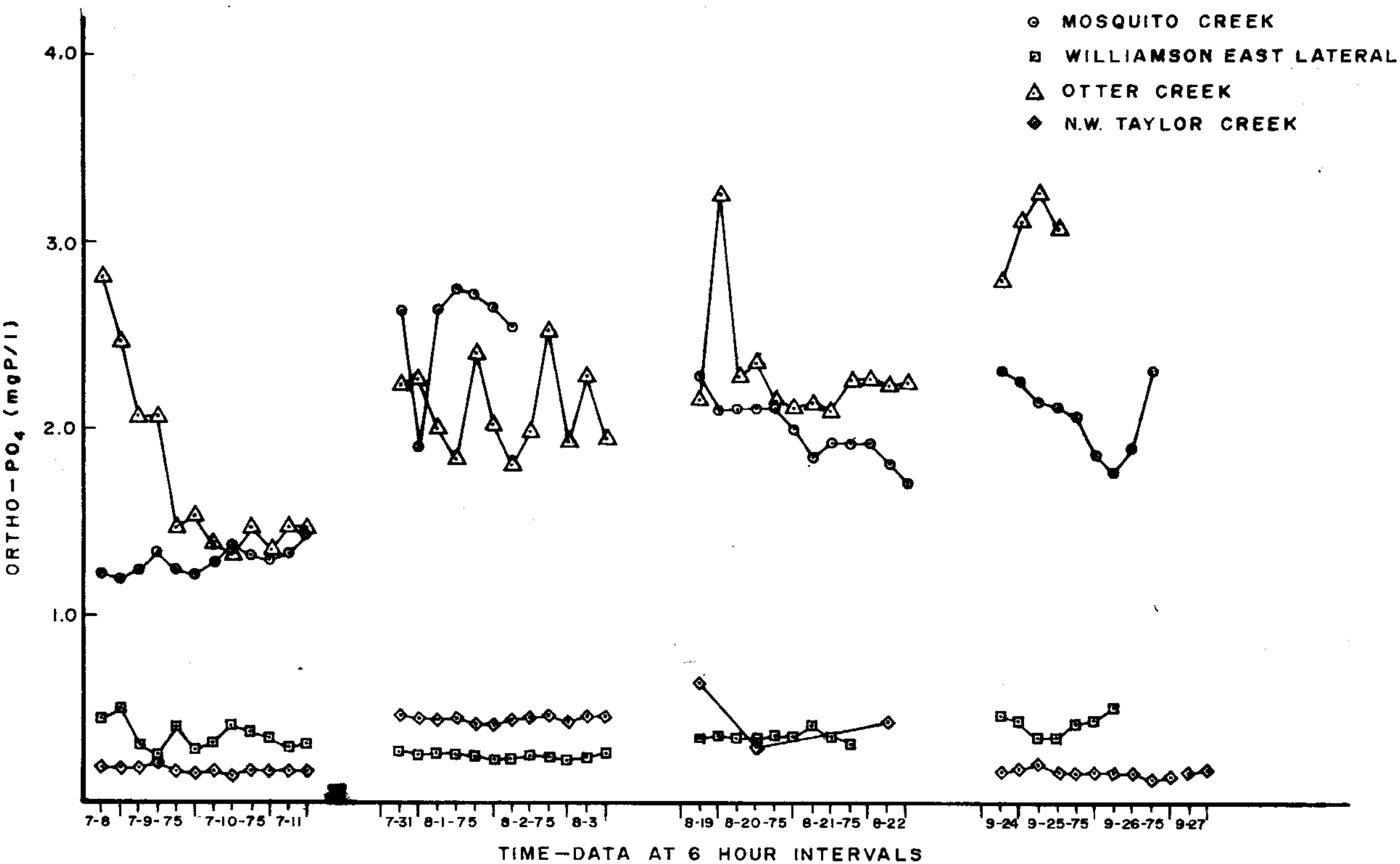

Figure 8 ORTHO PHOSPHORUS CONCENTRATIONS AS A FUNCTION OF TIME

and 6.21 mg/l, respectively, while averaging 6.97 and 2.97 mg/l (Table 4). Ammonia was the predominant nitrogen species present, averaging 3.53 mg N/l. Ammonia also appears to account for most of the variability in total N (Figures 3 to 6). Considerable oxygen demand could be exerted by the oxidation of the ammonia to nitrate, since it requires almost 4.5 mg O_2 per mg of ammonia -N oxidized (Brezonik 1973). Thus nitrification has the potential of depleting a significant amount of the oxygen in this area of Taylor Creek. Carbonaceous material may have an equal or greater potential oxygen demand than the nitrogen compounds, although no quantitative measurements were made. Nitrate and nitrite values were also unusually high, averaging 0.216 and 0.233 mg N/l, respectively. Phosphorus speciation was confined primarily to ortho-P which accounted for the majority of the total quantity (73 percent) and variability of phosphorus. In similar fashion to the previous stations, no pronounced diel patterns in nutrient fluctuations were observed (Figures 3 to 8).

The general water chemistry at Otter Creek can be characterized as being high in chlorides, sodium, and potassium (75.9, 40.4, and 14.3 mg/l, respectively) and moderately high in alkalinity (68.9 mg/l as $CaCO_3$).

<u>NW Taylor Creek</u>

Nutrient values presented in Table 4 indicate that the water at NW Taylor Creek is of a higher quality than that found at Mosquito Creek and Otter Creek, although it still can be considered to be in a degraded state. Total N remained fairly stable during the sampling periods at a mean level of 1.89 mg/l, with organic N representing 93 percent of this total. The order of fixed nitrogen species is organic N > NO_3^- > NH_4 > NO_2^-, indicating this is the only station where mean nitrate levels exceeded ammonia levels. Total P also remained relatively low at a mean concentration of 0.453 mg/l. Paralleling the other stations, ortho-P remained the dominant phosphorus species (66 percent), although organic-P increased in relative significance in quantity terms. Again there were no readily observable time-dependent fluctuations noted for any of the nutrient species.

The general water chemistry parallels nutrient water quality in terms of relatively low chloride (23.6 mg/l) and mineral levels (11.7 mg Na/l, 2.5 mg K/l, and 6.4 mg SiO_2/l.

IV. Statistical Analysis of Water Quality Data

A primary purpose of this study was to investigate the relationship between different land use practices and the quality of the associated runoff. Derived from this objective are three factors which this study attempts to account for in order to explain the areal variability in runoff quality: land use practices, temporal variation in water quality, and rainfall patterns. The objectives of the following statistical exercises, therefore, are fourfold:

1. To determine if land use patterns and/or temporal variation have a significant effect on the total N and P levels measured at each station.
2. To determine if land use patterns and/or temporal variation have a significant effect on the nitrogen speciation, phosphorus speciation and major ion composition measured at each station.
3. To determine if land use patterns and/or temporal variation have a significant effect on the overall water chemistry at each station as defined by the nine parameters measured in this study.
4. To determine the relative importance of different land use

categories on various water quality parameters.

For purposes of this study and to the degree presented in Table 1, different land use patterns were represented by four sub-basins of Taylor Creek, with the water quality of each being represented by a separate sampling station. Intraseasonal temporal variation was represented by four 72 hour diel sampling periods (Table 3). Since this study does not contain sufficient information to theoretically model the various aspects associated with rainfall (i.e., rainfall intensities, antecedent conditions, etc.) an alternative approach was employed in order to at least partially account for the effects of rainfall. Four simple variables were considered to have some importance in approximating the rainfall pattern within each sub-basin:

1. Total rainfall from beginning of the wet season through the sampling date.
2. Total time weighted rainfall from beginning of the wet season through the sampling date:

$$\sum_{i=1}^{N} \frac{d_i}{d_N} R_i \quad \text{where } d_N = \text{total number of days from beginning of wet season through sampling date} \tag{1}$$

$$d_i = i^{th} \text{ day } i = 1, \ldots, N$$

$$R_i = \text{rainfall in inches on } i^{th} \text{ day.}$$

3. Number of "wet days" from beginning of the wet season through the sampling date ("wet day" being defined as a day when at least 0.1 inches of rainfall was recorded).
4. Number of "wet periods" from beginning of wet season through sampling date (a single "wet period" being defined as any number of consecutive "wet days").

May 1, 1975 was chosen as the beginning of the wet season. In order to extract the maximum amount of information from these four variables, without including each one individually, a principal component analysis was performed. The first principal component (PC_1) explains the maximum amount variation in the variables (82 percent) and was calculated from the following equation derived using BMD01M (Dixon 1973):

$$PC_1 = -.5198\ (WD) - .4823\ (WP) - .4926\ (WR) - .5045\ (TR) \qquad (2)$$

where WD = no. of "wet days" from May 1st through sampling date

WP = no. of "wet periods" from May 1st through sampling date

WR = weighted rainfall from May 1st through sampling date

TR = total rainfall from May 1st through sampling date

The variables in the equation are standardized values (mean of zero and variance of one) of the observed variables (Table 5). The first principal component can be considered as a general rainfall "factor" with an increase in any of the variables causing a subsequent weighted increase in the value of the component. This first component was used to construct a rainfall factor (RF) according to the following equation:

$$RF = (-PC_1 + 7.23) \qquad (3)$$

The constant 7.23 was derived by substituting zero values (standardized) for the four variables into equation 2. This rainfall factor was used in further analysis to represent the pattern of rainfall. The potential usefulness of employing such a rainfall factor was lessened in this study since two of the sub-basins (Mosquito Creek and Williamson East Lateral) did not have separate rainfall gauging stations within them. Estimated rainfall for these two stations were calculated from the same pair of external gauging stations and therefore had the same values (Table 6). This in turn lessened the variability in the rainfall factor.

Results

In order to explore the first objective of whether land use patterns

TABLE 5. RAINFALL PARAMETERS AND ASSOCIATED RAINFALL FACTOR

Station	Sampling Date	Total Rainfall (inches)	Linear Weighted Rainfall (in.)	No. Wet Days	No. Wet Periods	Rainfall Factor
Mosquito Creek & Williamson East Lateral	7/8/75	13.45	7.21	38	9	5.19
	7/9	13.53	7.18	39	9	5.22
	7/10	13.82	7.38	40	9	5.30
	7/11	13.95	7.41	41	9	5.34
	7/31	17.15	8.59	53	12	6.41
	8/1	17.23	8.58	54	13	6.54
	8/2	17.23	8.49	54	13	6.52
	8/3	17.24	8.41	55	14	6.65
	8/19	21.33	11.02	66	16	7.86
	8/20	21.62	11.21	67	16	7.94
	8/21	21.67	11.16	68	16	7.96
	8/22	21.72	11.11	69	16	7.98
	9/24	27.47	13.27	91	21	9.87
	9/25	27.54	13.47	92	21	9.93
	9/26	27.83	14.13	93	21	10.08
	9/27	27.83	14.04	93	21	10.07
Otter Creek	7/8/75	11.35	7.43	39	11	5.32
	7/9	11.50	7.47	40	11	5.36
	7/10	11.68	7.55	41	11	5.41
	7/11	12.21	7.98	42	11	5.54
	7/31	15.32	8.33	51	14	5.67
	8/1	15.32	8.74	51	14	6.45
	8/2	15.32	8.65	51	14	6.44
	8/3	15.32	8.56	51	14	5.70
	8/19	20.24	11.98	59	18	4.99
	8/20	20.25	11.88	60	18	5.00
	8/21	20.35	11.88	61	18	7.99
	8/22	20.35	11.77	61	19	7.97
	9/24	25.28	13.64	79	22	9.54
	9/25	25.56	13.83	80	22	9.61
	9/26	25.57	13.75	81	22	9.63
	9/27	25.57	13.65	81	23	9.62
NW Taylor Creek	7/8/75	12.76	8.28	44	8	5.37
	7/9	13.25	8.65	45	8	5.49
	7/10	13.47	8.75	46	8	5.54
	7/11	13.69	8.85	47	8	5.60
	7/31	15.70	8.51	61	10	6.30
	8/1	15.70	8.42	61	10	6.29
	8/2	15.70	8.33	61	10	6.27
	8/3	15.93	8.48	62	11	6.44
	8/19	20.63	11.61	72	15	7.96
	8/20	20.64	11.52	73	15	7.97
	8/21	20.69	11.46	74	15	8.00
	8/22	20.69	11.36	74	15	7.98
	9/24	26.63	14.13	95	20	9.94
	9/25	26.99	14.40	96	20	10.04
	9/26	27.01	14.33	97	20	10.05
	9/27	27.01	14.23	97	20	10.04

TABLE 6. DAILY RAINFALL FOR THE FOUR SAMPLING BASINS

Day	Mosquito Creek and Williamson East Lateral					Otter Creek					NW Taylor Creek				
	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.
1		0.47	0.63	0.08	0.53			1.01		0.75		0.01	0.63		0.19
2		0.52	0.18				0.33					0.93	0.17		
3				0.01	0.07		0.02			1.06		0.02		0.23	0.82
4					0.10					0.19					0.53
5					0.06	0.09	0.08		0.16		0.13	0.21		0.71	0.02
6	0.18(1)		0.12		0.01			0.37	0.02			0.01	0.40	0.29	
7	0.48		0.15	0.56			0.44				0.02	0.33		0.02	
8	0.29		0.58(2)	0.67	0.07	0.48	0.20	1.01	1.36		0.19	0.23	0.85	1.42	
9	0.34		0.08	0.06	0.65	0.17	0.91	0.14	0.10	0.44	0.24	0.18	0.49	0.09	0.57
10	0.01		0.30	0.01	0.15	0.04		0.18	0.03	0.01	0.03	0.07	0.22	0.01	0.01
11		0.89	0.12	0.72	0.01			0.53		0.07	0.01	0.11	0.22		0.04
12	0.54	0.03	0.09	0.68	0.09	0.02		1.22	1.76	0.04	0.01		1.41	1.33	0.02
13	0.39		0.04	0.17	0.08	0.16		0.01	0.01	0.34	0.18		0.01		0.24
14	0.76		0.31	0.72	0.01	0.09		0.21		0.07	0.33		0.16		0.10
15	0.62	0.35	0.47	0.46	0.13	0.38	0.35			0.12	0.24		0.02	0.01	0.21
16	0.81	0.01	0.26		0.18	0.04				0.14	0.06		0.01	0.02	0.05
17	0.02	0.39	0.55		0.31	0.20		0.61		0.23	0.33		0.09		0.62
18	0.06	0.32	0.27	0.04	0.45	0.09	0.58			0.39	0.01	0.08	0.03		0.02
19	0.08	0.11		0.02	0.25		1.07		1.48	0.28		0.70	0.01	0.81	0.22
20		0.72		0.28			0.45	0.07	0.01	0.02		0.34	0.03	0.01	0.01
21			0.06	0.05			0.09		0.10					0.05	
22		0.65	0.01	0.05	0.98		0.69			0.60		1.41			0.20
23		0.39			0.05		0.15			0.15		0.30			0.43
24					0.07		0.57			0.03		1.90			0.01
25		1.29			0.29		0.22	0.57		0.28		0.26			0.36
26			0.03		0.75		0.02	0.29		0.01		0.01	0.11		0.03
27		0.08				0.12	0.03	0.01			0.32	0.28	0.01		
28		0.03				0.13	0.21			0.12	0.32	0.24	0.08		0.21
29	0.27	0.05	0.08	0.35	0.03	0.23	0.14			0.49	0.56	0.02		0.03	0.50
30	0.12	0.04	1.03	0.48	0.03	0.16	0.01			0.02	0.11	0.01	0.03		0.01
31	0.51					0.01		0.12			0.01		0.01	1.62	

(1) Rainfall measured in inches. (2) Sampling period.

or temporal variation have a significant effect on total N and P levels, a two-way analysis of variance (ANOVA) was performed. For comparative purposes, chloride was included as a third dependent variable to represent a conservative ion. The rainfall factor was employed as a covariate in order to help control extraneous variation in the dependent variables before the effects of station and sampling date were assessed. This helps to improve the precision of the test. The usefulness of using this covariate can partially be determined by examining the results presented in Tables 7 and 8. Prior to introducing the covariate both main effects, station and sampling date, were highly significant. After the covariate was added to the model, station remained highly significant while sampling date was reduced in significance. Specifically in the case of total P, sampling date was no longer significant at the 0.05 level. The covariate, therefore, accounted for some of the variation in the sampling date. Since in both analyses the cross product matrix could not be inverted, the two way interactions were not tested.

The hypothesis of equal sampling date effects was rejected when total N and chloride were considered as dependent variables but was not rejected when total P was considered (Table 8). This implies that the date of sampling significantly influences the levels of total N and chloride measured, but does not influence the levels of total P measured. However, the hypothesis of equal station effects was rejected for all three dependent variables, implying that the location of the sampling station significantly influences the measured levels of total N, total P, and chloride. Since the hypothesis of equal station effects was rejected, Duncan's Multiple Range Test was performed in order to determine which stations were significantly different from each other based upon the dependent variables total

TABLE 7. RESULTS OF TWO-WAY ANALYSIS OF VARIANCE

Dependent Variable: Total P

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Main Effects	202.987	18	11.277	46.942	0.001
Station	192.795	3	64.265	267.508	0.001
Sampling Date	6.566	15	0.438	1.822	0.036
Residual	34.594	144	0.240		
Total	237.581	162	1.467		

Dependent Variable: Total N

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Main Effects	903.262	18	50.181	59.380	0.001
Station	857.266	3	285.755	338.137	0.001
Sampling Date	46.984	15	3.132	3.706	0.001
Residual	131.834	156	0.845		
Total	1035.095	174	5.949		

Dependent Variable: Chloride

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Main Effects	3085963.5	18	171442.4	32.343	0.001
Station	2607424.2	3	869141.2	163.967	0.001
Sampling Date	453737.0	15	30249.1	5.707	0.001
Residual	826913.0	156	5300.7		
Total	3912876.6	174	22487.8		

NOTE: Since inversion of the cross-product matrix failed, the two-way interaction was eliminated.

TABLE 8. RESULTS OF TWO-WAY ANALYSIS OF VARIANCE WITH RAINFALL FACTOR AS COVARIATE

Dependent Variable: Total P

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Covariates	0.038	1	0.038	0.161	0.999
Rainfall Factor	0.038	1	0.038	0.161	0.999
Main Effects	203.742	18	11.319	47.886	0.001
Station	189.726	3	63.242	267.552	0.001
Sampling Date	4.100	15	0.273	1.156	0.312
Residual	33.801	143	0.263		
Total	237.581	162	1.467		

Dependent Variable: Total N

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Covariates	36.382	1	36.382	42.785	0.001
Rainfall Factor	36.382	1	36.382	42.785	0.001
Main Effects	866.911	18	48.162	45.638	0.001
Station	765.783	3	255.261	300.188	0.002
Sampling Date	33.068	15	2.205	2.593	
Residual	313.802	155	0.805		
Total	1035.095	174	5.949		

Dependent Variable: Chloride

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Covariates	345091.0	1	345091.0	65.298	0.001
Rainfall Factor	345091.0	1	345091.0	65.298	0.001
Main Effects	2748631.4	18	152701.7	28.894	0.001
Station	2562531.8	3	854177.3	161.627	0.001
Sampling Date	183162.1	15	12210.8	2.311	0.006
Residual	819154.1	155	5284.9		
Total	3912876.6	174	22487.8		

N, total P, and chloride. The results of these tests are presented in Table 9. Mean total N and P concentrations at Williamson East Lateral and NW Taylor Creek are not significantly different. Mean nutrient levels at Otter Creek, however, are significantly greater than those measured at Mosquito Creek while both these stations are significantly higher than Williamson East Lateral and NW Taylor Creek. Mean chloride concentration at Williamson East Lateral is significantly higher than the other stations while the levels at Otter Creek are significantly greater than that found at NW Taylor Creek. Chloride levels at Mosquito Creek are not significantly different from NW Taylor Creek and Otter Creek.

The second objective of determining whether land use patterns and/or temporal variation have a significant effect on phosphorus speciation, nitrogen speciation, and major ion composition was approached using multivariate analyses of variance (MANOVA). The dependent variables used in each respective test were: ortho-P and total P minus ortho-P as 2 phosphorus species; nitrite, nitrate, ammonia, and total organic nitrogen as 4 nitrogen species; and silica, chloride, sodium, and potassium as 4 major ions. Table 10a-c presents the results of the MANOVA's with respect to each of the three preceding cases. In all three instances the hypothesis of no differences among stations and no differences among sampling dates were rejected at the 0.01 level. The implication is that the phosphorus speciation, nitrogen speciation, and major ion composition are significantly affected by the sampling stations and dates. This further suggests that the land use patterns included in this study significantly affect the above parameters and that there is also significant temporal variation in the concentration of these species.

The third objective of determining whether land use patterns and/or

TABLE 9. RESULTS OF DUNCAN'S MULTIPLE RANGE TEST FOR TOTAL P, TOTAL N, AND CHLORIDE

Parameter	Station			
Total P	Williamson East Lateral	NW Taylor Creek	Mosquito Creek	Otter Creek
	0.436*	0.453	2.09	2.96
Total N	Williamson East Lateral	NW Taylor Creek	Mosquito Creek	Otter Creek
	1.61	1.89	2.88	6.97
Chloride	NW Taylor Creek	Mosquito Creek	Otter Creek	Williamson East Lateral
	23.6	53.2	75.9	330.1

Means not underscored by the same line are significantly different.

Means underscored by the same line are not significantly different.

* Mean concentration in mg/l

TABLE 10. RESULTS OF MULTIVARIATE ANALYSIS OF VARIANCE

a. Differences in Phosphorus Speciation

Hypothesis	F-statistic	d.f.		Significance
H_1	118.07	6	308	**
H_2	3.63	30	308	**
H_3	3.16	2	154	*

b. Differences in Nitrogen Speciation

Hypothesis	F-statistic	d.f.		Significance
H_1	45.61	12	402	**
H_2	2.76	60	596	**
H_3	10.04	4	152	**

c. Differences in Cation and Anion Composition

Hypothesis	F-statistic	d.f.		Significance
H_1	64.75	12	402	**
H_2	4.40	60	596	**
H_3	1.58	4	152	NS

d. Differences in General Water Chemistry

Hypothesis	F-statistic	d.f.		Significance
H_1	65.35	27	430	**
H_2	3.60	135	1159	**
H_3	6.126	9	147	**

Hypothesis: H_1 no differences among stations
H_2 no differences among sampling dates
H_3 covariate = 0

** sign. .01 level
* sign. .05 level
NS - not significant

temporal variation have a significant effect on the overall water chemistry, as defined by the nine parameters measured in this study, was approached again using MANOVA. The results of this analysis using ortho-P, total P minus ortho-P, NO_x ($NO_3^- + NO_2^-$), ammonia, total organic nitrogen, silica, sodium, potassium, and chlorides as dependent variables are presented in Table 10d. Since the H_1 and H_2 hypotheses of equal station effects and equal sampling date effects were rejected, a significant difference among stations and sampling dates is implied. This suggests that the different land use patterns significantly affect the general water quality at each station and in addition there are significant temporal variations in the water quality at each station.

The fourth objective of determining the relative importance of different land use categories on the level of various water quality parameters was approached through a series of linear regressions. Table 11 presents the results of stepwise regression analysis using the percent area of each land use category (Table 1) and the rainfall factor (Table 5) as independent variables and the $\log_{10}$ transformation of each chemical parameter as dependent variables. The dependent variables were log transformed in order to improve the fit of the regression equations. Since marsh and cropland appear as viable land use categories only in the NW Taylor Creek sub-basin and in the same proportions, they are perfectly correlated. Therefore for statistical purposes only one of the variables, percent marsh, was included as an independent variable. Consequently in further discussions, marsh and cropland can be considered to be synonymous, with any effect attributable to one category being also attributable to the other.

Included in Table 11 are the weightings for the independent variables, the order of their inclusion into the equation, and the multiple R^2

TABLE 11. RESULTS OF STEPWISE LINEAR REGRESSION ANALYSIS

Log Transformed Dependent Variable	Weightings for Independent Variables: Dairy % Operations	% Improved Pasture	% Swamp	% Marsh (% Crop)	% Citrus	Rainfall Factor	Constant	Multiple R^2
NO_x		.0952(1)	-.2129(2)		.3728(3)	.0139(4)*	-8.326	0.274
NO_3		-.1149(1)		.0832(2)	-.0425(3)	-.0315(4)*	7.728	0.171
NO_2	-.0035(1)	-.1400(2)			-.0951(3)	.0146(4)*	9.721	0.428
NH_4	.0673(1)	.0260(4)		-.1565(2)		.0836(3)	-2.40	0.825
Inorganic N	.0381(1)		-.0343(4)	-.1258(3)		-.0739(2)	.2714	0.798
TKN	.0281(1)	-.0008(4)		.0175(3)		-.0229(2)	.4106	0.835
TON	.0139(1)	-.0047(4)		.0296(2)		-.0180(3)	.6432	0.611
Total N	.0288(1)	-.0039(4)*		.0212(3)		-.0219(2)	.677	0.863
Ortho-P	.0403(1)	.0714(3)		-.1227(2)		.0187(4)	-6.28	0.901
Total P	.0827(1)	.1420(2)			.1207(3)	.0198(4)	-12.61	0.914
Total P - Ortho P	.0489(1)			.0625(2)		.0306(3)	-1.42	0.574
SiO_2			.0010(4)	-.0472(1)	-.0084(2)	-.0053(3)	1.03	0.658
Cl		-.0105(4)*		-.0885(2)	.1021(1)	-.0474(3)	2.97	0.827
Na		-.0079(4)*		-.1025(2)	.1005(1)	-.0606(3)	2.60	0.910
K	.0148(2)	-.0028(4)*		-.1012(1)		-.0113(3)	1.13	0.890

NOTE: Number in ( ) indicates order in which variables were entered into regression equation. Variables not entered into the equations are blank.

* Not significant at 0.05 level.

values. All the regression equations except those with NO_x, NO_2^- and NO_3^- as dependent variables had R^2 values which exceeded 0.57. The response of NO_x, NO_2^- and NO_3^- was not adequately predicted by a linear regression model involving land use and rainfall factors and therefore will be excluded from the following discussion. In general, the order in which the independent variables were entered can be considered as a relative indication of their importance in influencing the levels of the dependent water quality parameters. In all the regressions involving nutrient forms, percent dairy operations was the first variable entered into the equation. This suggests that in the context of the land use systems investigated, dairy operation is the most important factor in accounting for high nutrient levels. Additional variables entered into the regression equations include the rainfall factor, percent marsh (percent crops), percent improved pasture, and percent swamp. Although this is the general order in which the variables were entered, variations are common. For three of the dependent variables, TKN, inorganic N, and total N, the rainfall factor was the second variable entered into the equations. In the case of ammonia, total organic N, and ortho-P, percent marsh (crop) was the second variable entered. There is no common trend in the variables entered in the third and fourth steps. Computations ceased after the fourth step due to insufficient F or tolerance levels.

When the sodium and chloride ions are considered as dependent variables, percent citrus is the first variable introduced into the equation followed by percent marsh (crop) and the rainfall factor. In the case of silica and potassium, percent marsh (crop) is considered as the single most important land use category. The second variable entered into the silica equation was percent citrus while percent urban area was entered next in the potassium equation. The rainfall factor was entered third in both equations.

DISCUSSION

General Chemistry

The four stations sampled in this study present varying stages of water quality. In terms of biogenic parameters, the general ranking of the stations are: Otter Creek > Mosquito Creek > NW Taylor Creek > Williamson East Lateral. For these stations the corresponding total N and P levels averaged 6.97 and 2.97, 2.88 and 2.09, 1.89 and 0.453, 1.61 and 0.44 mg/l, respectively. The dominant nitrogen species shifts from organic N for Williamson East Lateral, NW Taylor Creek, and Mosquito Creek to ammonia for the most degraded station, Otter Creek. Mosquito Creek and Otter Creek have sufficiently high ammonia concentrations (1.08 and 3.53 mg NH_4 - N/l, respectively) so that nitrification has the potential of depleting a significant quantity of oxygen (4.5 mg O_2 per mg of NH_4-N) in their respective areas of the Taylor Creek basin. Carbonaceous oxygen demand, however, may have an equal or greater potential for oxygen depletion.

Opposingly, when sodium and chloride are considered as the master variables, the general order of the stations is: Williamson East Lateral > Otter Creek > Mosquito Creek > NW Taylor Creek, with the corresponding levels averaging 165.8 and 330.1, 40.4 and 75.9, 30.0 and 53.2, 11.7 and 23.6 mg/l, respectively. The order is changed to: Otter Creek > Mosquito Creek > Williamson East Lateral > NW Taylor Creek, based on potassium and silica. Imported dairy cattle feed could account for the high potassium levels found in the Otter Creek and Mosquito Creek stations.

Comparatively, Omernik (1976) reported mean nutrient runoff concentrations for 473 sub-basins according to six overall land use categories. The two land use divisions which correspond the closest to those presented in this study are agricultural (>75 percent agriculture and >7 percent urban) and mostly agricultural (>50 percent agriculture and not included in agricultural category). According to Omernik's classification, Mosquito Creek and Otter Creek would be considered as mostly agricultural, while Williamson East Lateral and NW Taylor Creek would be classified as agricultural. The mean total N and P concentrations for 91 agricultural sub-basins were 4.17 and 0.135 mg/l, respectively, while for 96 mostly agricultural sub-basins total N and P averaged 1.812 and 0.066 mg/l, respectively. The corresponding total N to total P ratios for these two categories were 31:1 and 27:1, respectively. Mosquito Creek and Otter Creek both greatly exceed the above mean nutrient concentrations for mostly agricultural areas. Mean total N levels for Williamson East Lateral and NW Taylor Creek are less than those reported for agricultural areas, while mean total P levels greatly exceed the agricultural area levels. Greater differences are found in the N:P ratios. Total N to total P ratios for Williamson East Lateral and NW Taylor Creek were 3.7:1 and 2.4:1 while for Mosquito Creek and Otter Creek they averaged 1.4:1 and 2.4:1. This indicates a large phosphorus imbalance when compared to other predominantly agricultural areas in the United States. According to Vollenweider (1968) the four Taylor Creek sub-basins would be considered as being nitrogen limited (N:P ratio less than 14:1). Differences in the N:P ratios between those found in the Taylor Creek basin and those reported by Omernik may be partially attributable to soil composition. Soils within the Taylor Creek watershed are sandy and acidic containing little reactive clay, ferric oxide, or calcium to tie up the phosphorus. Therefore, relatively more P may be in the liquid phase than in the sediment fraction, which would result in lower N:P ratios. The opposite may occur in other regions of the country where there may be more reactive soils to tie up the phosphorus. This would, in turn, tend to increase the N:P ratio.

More direct comparisons can be made between the data collected during this study and that reported by Allen et al. (1976) and Federico and Brezonik (1975). Figure 9 displays the relevant Taylor Creek sample site locations found in each of the three studies. There is good agreement between sample site locations with the exception of the Williamson East Lateral station. For this station, the location found in Federico and Brezonik (1975) is further downstream than this study and the ARS study and represents a larger drainage area. Table 12 presents mean values of selected parameters from each study for the months of July through September. There appears to be good accord between the parameters reported in the three studies with the values measured in this study falling in between those found in the other two reports.

Statistical Analysis

The two basic objectives of the statistical analysis were to: (1) determine if land use patterns and/or temporal variation significantly affect total N, total P, nutrient speciation, major ion composition, and the general water chemistry at each station, and (2) to attempt to determine the relative importances of different land use categories and rainfall on the quality of runoff. Interpretation of the results of the statistical analyses in the above context requires the defining of certain equalities. Specifically, sampling station is assumed to be synonymous with and representative of the land use patterns in its respective sub-basins with both being considered as fixed quantities. Temporal variation is assumed to be adequately defined by the established diel sampling periods since it is the only time-dependent variable considered in this study.

Results of the ANOVA and MANOVA procedures indicate that station (land use patterns) significantly influence both the total N and P levels in the runoff and the speciation of their respective forms. Sampling date (temporal variation), was found to significantly influence total N levels but not total P levels while significantly influencing both N and P speciation.

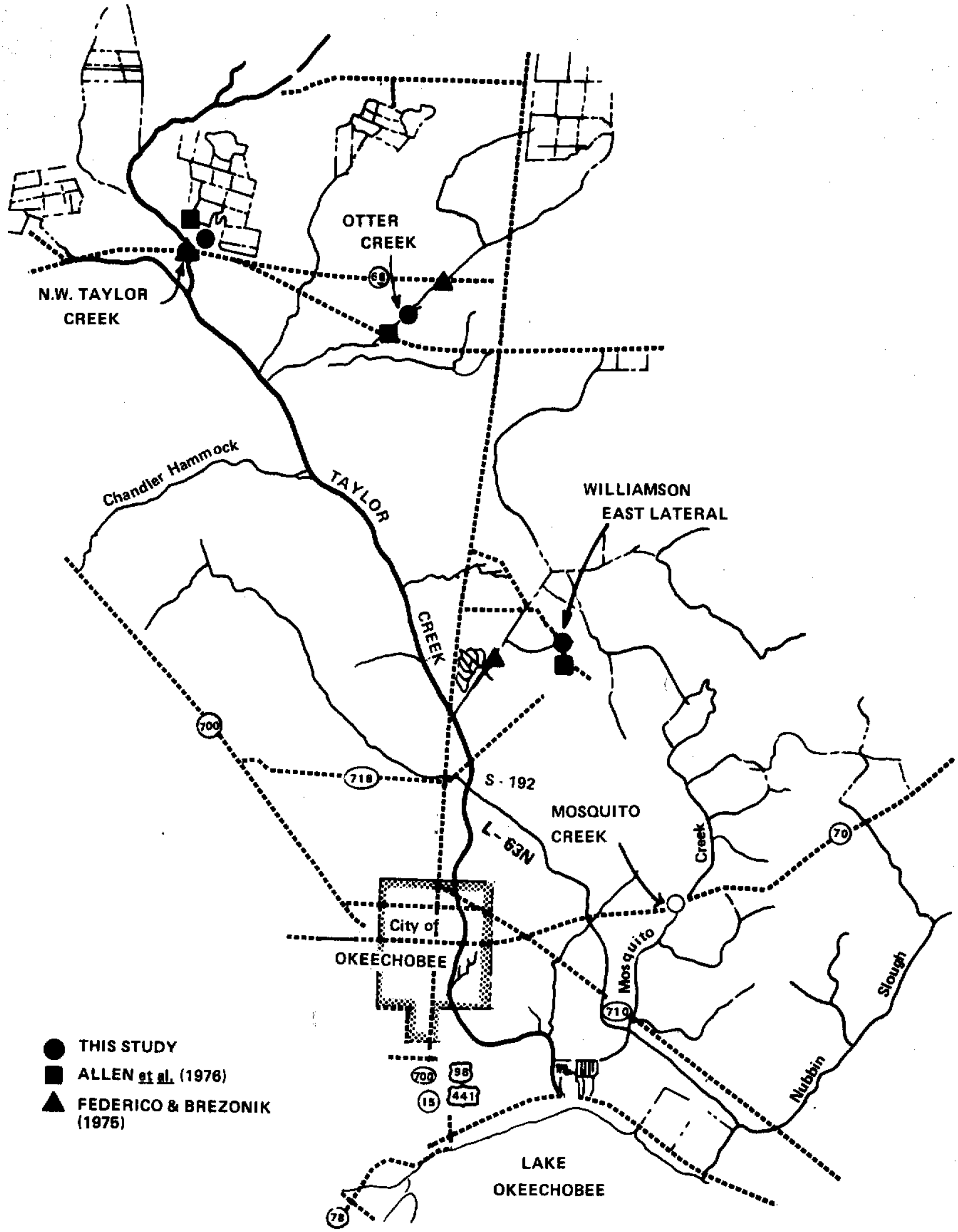

FIGURE 9. COMPARISON OF STATION LOCATIONS FOR TAYLOR CREEK

TABLE 12. COMPARISON OF SELECTED WATER CHEMISTRY DATA FOR TAYLOR CREEK

Source	Selected Sampling Periods	Parameter*	Williamson E. Lateral	Otter Creek	NW Taylor Creek
Allen *et al.* (1976)	July 1972 to Sept. 1972	Ortho-P	0.38	2.20	0.94
		NO_3^- -N	0.34	0.62	0.37
		Cl^-	1967	183	138
Federico & Brezonik (1975)	July and Sept. 1974	Total-P	0.69	4.28	3.4
		Ortho-P	0.55	2.90	0.46
		TKN	1.79	9.90	1.30
		NO_3^- -N	0.12	0.19	0.16
		NH_4 -N	0.37	4.80	0.15
		Cl^-	299	35	15
This study	July to Sept. 1975	Total-P	0.436	2.97	0.453
		Ortho-P	0.372	2.16	0.297
		TKN	1.54	6.52	1.81
		NO_3^- -N	0.05	0.216	0.074
		NH_4 - N	0.15	3.53	0.05
		Cl^-	330	76	24

* Concentrations in mg/l

Duncan's Multiple Range Test indicates that mean total N and P levels at Otter Creek were significantly higher than Mosquito Creek with both significantly higher than either Williamson East Lateral or NW Taylor Creek. These latter two stations were not significantly different. Land use patterns and temporal variation were also found to significantly affect the ionic composition and the overall water chemistry at each station. A nonstatistical extrapolation of these results would indicate that the different land use patterns significantly affect total N, total P, nutrient speciation, ionic composition, and general water chemistry of the runoff measured at each station. Temporal variation was likewise found to significantly affect these aspects of water quality. The rainfall factor accounted for the temporal variation in total P.

The useful physical interpretation of the stepwise regression analysis dictates that the order in which the variables were entered be considered as their relative importance in influencing the concentration of the measured water quality parameter. Consideration must also be given to the relatively arbitrary division of land uses into separately defined classes. The type of land use classes used in this study, although widely employed, measure only the area of land devoted to a use but do not measure the intensity of the use. This may not be the best classification in terms of relating the quality of runoff to land use practices. Specifically, in this study dairy operations were quantified in terms of the land area covered by the actual dairy buildings and associated labor housing. It was therefore necessary to assume that the more dairy cows serviced by a particular dairy complex, the larger would be that complex's facilities (buildings). However, the quantitative relationship between the number of dairy cows and the size of the complex is unknown and may be noncontinuous.

In addition, all land designated as improved pasture was weighted equally even though some pastures, such as those which service dairy operations, carry more cows than other non-dairy pastures. Some other parameter which measures land use intensity, such as cattle or crop density, might have been a more appropriate measure of land use.

Under the above assumptions and considerations, dairy operations can be considered the most important land use type influencing the nutrient parameters, since it was the first independent variable entered in all the significant regression equations. Percent citrus influences sodium and chloride to the greatest degree, although this effect may not be a result of a land use type per se. The relationship may be more a result of the use of saline artesian irrigation water ($\sim$1840 mg/l as Cl). Potassium and silica are influenced the greatest by percent marsh (cropland). The rainfall factor was entered as a significant variable in all the regression equations with multiple R^2 greater than 0.57.

CONCLUSIONS

Presented below are the conclusions concerning the water quality in four sub-basins of Taylor and Mosquito Creeks during the 1975 wet season. It should be noted that these conclusions are derived from a spatially and temporally limited data base and that extrapolation to other systems or time frames could result in unjustifiable conclusions.

The general ranking of the sampling stations in terms of nutrient water quality was Otter Creek (6.97 mg N and 2.97 mg P/l) > Mosquito Creek (2.88 mg N and 2.09 mg P/l) > NW Taylor Creek (1.89 mg N and 0.453 mg P/l) > Williamson East Lateral (1.61 mg N and 0.436 mg P/l). Otter Creek was significantly higher in total N and P than Mosquito Creek which were both significantly higher than Williamson East Lateral and NW Taylor Creek. The former two stations represent the only sub-basins which contained significant dairy operations. In addition, station location (i.e., upstream land use patterns) and time of sampling significantly influenced both the total levels of N and P and the speciation of these nutrients. When the variation due to rainfall was controlled, the time of sampling no longer significantly influenced total P levels. These two factors, land use patterns and time of sampling, also significantly influenced the cation composition and the general water quality (based on nine chemical parameters). In terms of the conservative chloride ion, Williamson East Lateral is significantly higher than the remainder of the stations, while Otter Creek was significantly higher than Mosquito Creek and NW Taylor Creek. Williamson East Lateral was the only station influenced by citrus while NW Taylor Creek was the only station influenced by cropland.

Based on linear stepwise regression analysis, dairy operations were considered as being the dominant land use type influencing total N and P levels and speciation. Citrus was shown to be the primary land use type influencing sodium and chloride levels (primarily as a result of saline artesian irrigation water) while marsh (cropland) was considered to be the primary influence on potassium and silica levels.

In summary, the following preliminary conclusions can be extracted from the available data based on the assumptions previously discussed:

1. Surface waters in Otter Creek and Mosquito Creek contain very high levels of total N (6.97 and 2.88 mg N/l) and total P (2.97 and 2.09 mg P/l).
2. Surface waters in Williamson East Lateral contain extremely high chloride levels (330.1 mg/l).
3. Rainfall appears to affect the total nutrient levels, nutrient speciation (except for NO_2^- and NO_3^-), and ionic composition in the four sub-basins. The rainfall factor appears to account for some of the temporal variation in phosphorus.
4. Dairy farm operations appear to be significant sources of nitrogen and phosphorus.
5. Improved pastures appear to be significant sources of nitrate.
6. Citrus groves appear to be significant sources of sodium and chloride.
7. Marshes and/or cropland appear to be significant sources of potassium and silica.

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APPENDIX A

ANALYTICAL METHODS

AUTOANALYZER

Determination	Method	Range	Sensitivity
Alkalinity	1. Methyl Orange; Technicon AutoAnalyzer II, method #111-71W	0-10 meq/l	0.10 meq/l 2% of full scale
	2. Potentiometric titration Ref. Standard Methods, 13th Edition, p. 52-56.	0-10 meq/l	0.3 meq/l
Ammonia	Berthelot reaction Technicon AA II, method #154-71W Ref: D. D. Van Slyke & A. J. Hillen, Bio Chem. 102, p. 499, 1933; S. Kallman, Presentation, April 1967, San Diego, Calif.; W. T. Bolleter, C. J. Bushman & P. N. Tidwell, Anal. Chem. 33, p. 592, 1961; J. A. Tellow & A. L. Wilson, Analyst, 89, p. 453, 1964; A. Tarugi & F. Lenci, Boll Chim Farm, 50, p. 907, 1912; FWPCA Methods of Chem. Anal. of Water & Waste Water. Nov. 1969, p. 137.	0-0.50 ppm	0.010 ppm 2% of full scale
Chloride	Ferric Thiocyanate complex Technicon AA II, method #99-70W Ref: Automatic Analysis of Chlorides in Sewage, James E. O'Brien, Wastes Engineering, Dec. 1962; D. M. Zall, D. Fisher & M. D. Garner, Anal. Chem. 28, 1956, p. 1665	0-200 ppm	4.0 ppm 2% of full scale
Nitrite	Diazotization method which couples with N-1-naphthylene-diamine dihydrochloride. Technicon AA II; method #120-70W, modified for linear sensitivity. Ref: Standard Methods, 12th edition, 1965, p. 205	0-0.200 ppm	.004 ppm 2% of full scale
Nitrate	Same as Nitrite with Cadmium Reduction column Technicon AA II, method #100-70W, modified for linear sensitivity.	0-0.200 ppm	.004 ppm 2% of full scale

APPENDIX A (Continued)

AUTOANALYZER

Determination	Method	Range	Sensitivity
Nitrogen, Total Kjeldahl	Digestion with H_2SO_4 and HgO catalyst followed by Ammonia determination as described above, modified diluent reagent to neutralize Kjeldahl digestion mixture. Technicon AA II, method #146-71A Ref. Standard Methods, 13th edition, p.244	0-3.0 ppm	0.06 2% of full scale
Ortho-Phosphate	Phosphomolybdenum blue complex with ascrobic acid reduction. Technicon AA II; method #155-71W Ref: J. Murphy & J. P. Riley, Anal. Chim. Acta, 27, p. 30, 1962.	0-0.100 ppm	.002 2% of full scale
Phosphate, Total	Same as Ortho-Phosphate with persulfate digestion. Modified Standard Methods procedure: 13th edition, p. 525, 1971. Technicon AA II; method #93-70W.	0.0.100 ppm	.002 2% of full scale
Silicate	Ascorbic acid reduction of silicomolybdate complex to "Molybdenum blue" Technicon AA II Method #105-71W.	0-20 ppm	0.4 ppm 2% of full scale

ATOMIC ABSORPTION

Parameter	Wavelength	Flame	Comments
Sodium	589.0 nm-vis. (SLIT 1.4 nm)	Air and acetylene	Dual capillary system (DCS) as described by T. H. Miller and W. H. Edwards, Atomic Absorption Newsletter 15, No. 3 (1976).
Potassium	766.5 nm-vis. (SLIT 1.4 nm)	Air and acetylene	Sample treatment as described for sodium.

APPENDIX B

TAYLOR CREEK WATER CHEMISTRY DATA

Units in mg/l except as follows:

Nutrient forms: mg N or P/l

Alkalinity: mg/l as $CaCO_3$

NO_x = $NO_2 + NO_3$

TN = Total Nitrogen

TP = Total Phosphorus

O-P = Ortho-Phosphorus

All samples were collected at the surface.

Blank indicates missing data.

< indicates results less than quoted limit of sensitivity.

APPENDIX B. LABORATORY RESULTS FOR SAMPLING DATES

1. Mosquito Creek

Date Mo/day/yr	Time Hour, min.	NO_x	NO_2		NO_3	NH_4	TKN
7/ 8/75	1300.	0.016	0.012	<	0.004	0.50	2.42
7/ 8/75	1900.	0.017	0.009		0.008	0.43	2.37
7/ 9/75	100.	0.048	0.009		0.039	0.49	2.52
7/ 9/75	700.	0.036	0.011		0.025	0.55	2.64
7/ 9/75	1300.	0.018	0.014	<	0.004	0.50	2.49
7/ 9/75	1900.	0.016	0.012	<	0.004	0.59	2.64
7/10/75	100.	0.321	0.010		0.311	0.77	2.96
7/10/75	700.	0.017	0.013	<	0.004	1.10	2.97
7/10/75	1300.	0.077	0.010		0.067	1.10	3.03
7/10/75	1900.	0.024	0.014		0.010	1.15	3.65
7/11/75	100.	0.030	0.011		0.019	1.10	3.12
7/11/75	700.	0.015	0.011	<	0.004	1.27	3.29
7/31/75	1300.	0.118	0.007		0.111	4.16	4.83
7/31/75	1900.	0.179	0.008		0.171	1.84	3.28
8/ 1/75	100.	0.010	0.008	<	0.004	2.75	4.88
8/ 1/75	700.	0.016	0.007		0.009	3.15	5.05
8/ 1/75	1300.	0.059	0.030		0.029	3.18	5.39
8/ 1/75	1900.	0.036	0.027		0.009	2.95	5.13
8/ 2/75	100.	0.235	0.025		0.210	2.93	4.88
8/19/75	1300.	0.018	0.014		0.004	0.94	2.69
8/19/75	1900.	0.030	0.011		0.019	0.70	2.37
8/20/75	100.	0.084	0.011		0.073	0.83	2.58
8/20/75	700.	0.017	0.010		0.007	0.93	2.74
8/20/75	1300.	0.017	0.010		0.007	1.25	3.04
8/20/75	1900.	0.016	0.009		0.007	1.07	2.76
8/21/75	100.	0.016	0.009		0.007	1.02	2.72
8/21/75	700.	0.018	0.009		0.009	1.24	2.96
8/21/75	1300.	0.017	0.009		0.008	1.40	3.32
8/21/75	1900.	0.088	0.009		0.079	1.39	3.14
8/22/75	100.	0.020	0.009		0.011	1.46	3.36
8/22/75	700.	0.016	0.009		0.007	1.61	3.67
9/24/75	1300.	0.052	0.008		0.044	0.05	1.31
9/24/75	1900.	0.010	0.008	<	0.004	0.04	1.35
9/25/75	100.	0.011	0.010	<	0.004	0.04	1.42
9/25/75	700.	0.022	0.007		0.015	0.05	1.39
9/25/75	1300.	0.008	0.010			0.02	1.39
9/25/75	1900.	0.026	0.007		0.019	0.07	1.30
9/26/75	100.	0.187	0.008		0.179	0.09	1.50
9/26/75	700.	0.010	0.008	<	0.004	0.03	1.37
9/26/75	1300.	0.014	0.012	<	0.004	0.40	1.81
9/26/75	1900.	0.019	0.011		0.008	0.40	1.97
9/27/75	100.	0.012	0.010	<	0.004	0.41	1.88
9/27/75	700.	0.259	0.010		0.249	0.54	2.04

APPENDIX B-1 (CONTINUED)

Date Mo/day/yr	Time Hr/Min.	TN	O-P	TP	SiO_2	Na
7/ 8/75	1300.	2.44	1.225	1.360	8.8	32.10
7/ 8/75	1900.	2.39	1.198	1.263	8.9	32.90
7/ 9/75	100.	2.57	1.237	1.307	8.6	34.20
7/ 9/75	700.	2.68	1.341	1.419	8.7	34.20
7/ 9/75	1300.	2.51	1.245	1.350	9.0	32.90
7/ 9/75	1900.	2.66	1.221	1.356	9.0	32.90
7/10/75	100.	3.28	1.290	1.436	8.9	33.30
7/10/75	700.	2.99	1.378	1.543	8.9	34.20
7/10/75	1300.	3.11	1.331	1.419	9.1	35.80
7/10/75	1900.	3.67	1.307	1.439	9.1	34.20
7/11/75	100.	3.15	1.337	1.385	9.4	33.30
7/11/75	700.	3.31	1.450	1.574	9.3	33.30
7/31/75	1300.	4.95	2.635	2.788	10.8	40.75
7/31/75	1900.	3.46	1.903	1.957	9.7	37.58
8/ 1/75	100.	4.89	2.631	2.838	10.9	37.58
8/ 1/75	700.	5.07	2.743	2.904	11.0	38.48
8/ 1/75	1300.	5.45	2.724	2.888	11.9	40.75
8/ 1/75	1900.	5.17	2.645	2.777	11.2	39.39
8/ 2/75	100.	5.12	2.552	2.586	11.1	38.26
8/19/75	1300.	2.71	2.288	2.554	10.5	26.15
8/19/75	1900.	2.40	2.103	2.345	10.4	25.46
8/20/75	100.	2.66	2.108	2.335	10.4	24.92
8/20/75	700.	2.76	2.118	2.330	10.4	25.25
8/20/75	1300.	3.06	2.108	2.319	10.3	25.68
8/20/75	1900.	2.78	2.002	2.183	10.4	25.79
8/21/75	100.	2.74	1.854	2.215	10.8	26.12
8/21/75	700.	2.98	1.916	2.241	10.7	26.66
8/21/75	1300.	3.34	1.928	2.267	10.7	26.99
8/21/75	1900.	3.23	1.924	2.225	10.7	26.77
8/22/75	100.	3.38	1.822	2.194	10.7	27.42
8/22/75	700.	3.69	1.712	2.116	11.2	27.86
9/24/75	1300.	1.36	2.304	2.552	10.1	26.77
9/24/75	1900.	1.36	2.261	2.480	10.1	28.41
9/25/75	100.	1.43	2.155	2.345	10.1	22.03
9/25/75	700.	1.41	2.117	2.200	10.0	25.14
9/25/75	1300.	1.40	2.078	2.112	10.0	25.47
9/25/75	1900.	1.33	1.879	1.973	10.0	25.14
9/26/75	100.	1.69	1.776	1.934	9.6	25.79
9/26/75	700.	1.38	1.901	1.787	9.5	23.50
9/26/75	1300.	1.82	2.326	2.687	9.2	23.83
9/26/75	1900.	1.99	2.261	2.521	9.1	23.83
9/27/75	100.	1.89	1.993	2.273	8.6	24.48
9/27/75	700.	2.30	2.056	2.231	8.7	24.48

APPENDIX B-1 (CONTINUED)

Date Mo/day/yr	Time Hour, Min.	K	Cl	Alkalinity
7/ 8/75	1300.	5.22	53.6	
7/ 8/75	1900.	5.00	54.8	
7/ 9/75	100.	5.22	59.0	
7/ 9/75	700.	5.36	58.0	
7/ 9/75	1300.	5.19	58.6	
7/ 9/75	1900.	5.98	57.8	
7/10/75	100.	6.29	60.0	
7/10/75	700.	6.60	63.4	
7/10/75	1300.	5.75	64.6	
7/10/75	1900.	6.40	61.4	
7/11/75	100.	6.69	62.6	
7/11/75	700.	6.86	61.8	
7/31/75	1300.	10.96	62.3	
7/31/75	1900.	8.37	60.5	
8/ 1/75	100.	11.74	60.4	
8/ 1/75	700.	11.85	61.7	
8/ 1/75	1300.	13.99	62.3	
8/ 1/75	1900.	13.28	60.5	
8/ 2/75	100.	12.11	64.2	
8/19/75	1300.	9.46	42.3	93.0
8/19/75	1900.	9.19	43.5	89.5
8/20/75	100.	9.31	44.7	88.0
8/20/75	700.	9.22	51.7	93.0
8/20/75	1300.	9.33	43.5	93.0
8/20/75	1900.	9.14	43.5	93.0
8/21/75	100.	9.06	43.5	89.5
8/21/75	700.	9.36	49.5	87.5
8/21/75	1300.	9.48	46.7	93.5
8/21/75	1900.	9.56	45.3	94.5
8/22/75	100.	9.55	45.3	93.0
8/22/75	700.	9.70	44.9	90.5
9/24/75	1300.	10.03	52.7	
9/24/75	1900.	9.85	51.7	
9/25/75	100.	9.72	48.9	
9/25/75	700.	9.74	53.1	
9/25/75	1300.	9.74	48.9	
9/25/75	1900.	9.72	52.1	
9/26/75	100.	9.37	46.7	
9/26/75	700.	9.43	49.1	
9/26/75	1300.	10.16	47.7	
9/26/75	1900.	10.03	45.5	
9/27/75	100.	9.70	48.9	
9/27/75	700.	9.65	48.7	

APPENDIX B. LABORATORY RESULTS FOR SAMPLING DATES

2. Williamson East Lateral

Date Mo/day/yr	Time Hour, min.	NO_x	NO_2	NO_3	NH_4	TKN
7/ 8/75	1300.	0.022	0.011	0.011	0.38	1.85
7/ 8/75	1900.	0.118	0.016	0.102	0.36	1.82
7/ 9/75	100.	0.070	0.019	0.051	0.31	1.60
7/ 9/75	700.	0.033	0.014	0.019	0.22	1.73
7/ 9/75	1300.	0.146	0.017	0.129	0.29	1.73
7/ 9/75	1900.	0.048	0.018	0.030	0.14	1.74
7/10/75	100.	0.101	0.018	0.083	0.17	1.69
7/10/75	700.	0.040	0.015	0.025	0.25	1.35
7/10/75	1300.	0.076	0.016	0.060	0.17	1.20
7/10/75	1900.	0.054	0.024	0.030	0.25	1.17
7/11/75	100.	0.052	0.015	0.037	0.24	1.56
7/11/75	700.	0.061	0.013	0.048	0.23	1.70
7/31/75	1300.	0.039	0.020	0.019	0.15	1.54
7/31/75	1900.	0.040	0.017	0.023	0.15	1.59
8/ 1/75	100.	0.039	0.018	0.021	0.15	1.58
8/ 1/75	700.	0.050	0.023	0.027	0.15	1.57
8/ 1/75	1300.	0.087	0.033	0.054	0.19	1.68
8/ 1/75	1900.	0.054	0.023	0.031	0.12	1.53
8/ 2/75	100.	0.063	0.024	0.039	0.14	1.51
8/ 2/75	700.	0.064	0.025	0.039	0.15	1.53
8/ 2/75	1300.	0.055	0.023	0.032	0.14	1.48
8/ 2/75	1900.	0.069	0.021	0.048	0.07	1.58
8/ 3/75	100.	0.056	0.024	0.032	0.12	1.58
8/ 3/75	700.	0.124	0.022	0.102	0.16	1.54
8/19/75	1300.	0.016	0.008	0.008	0.09	1.58
8/19/75	1900.	0.015	0.008	0.007	0.08	1.43
8/20/75	100.	0.031	0.008	0.023	0.10	1.35
8/20/75	700.	0.027	0.009	0.018	0.05	1.43
8/20/75	1300.	0.355	0.010	0.345	0.07	1.35
8/20/75	1900.	0.074	0.005	0.069	0.08	1.29
8/21/75	100.	0.014	0.006	0.008	0.01	1.39
8/21/75	700.	0.018	0.009	0.009	0.04	1.41
8/21/75	1300.	0.031	0.007	0.024	0.05	1.46
9/24/75	1300.	0.045	0.012	0.033	0.13	1.46
9/24/75	1900.	0.043	0.013	0.030	0.15	1.48
9/25/75	100.	0.032	0.011	0.021	0.11	1.42
9/25/75	700.	0.036	0.011	0.025	0.06	1.50
9/25/75	1300.	0.034	0.012	0.022	0.05	1.48
9/25/75	1900.	0.034	0.008	0.026	0.10	1.65
9/26/75	100.	0.081	< 0.004	0.077	0.05	1.47
9/26/75	700.	0.037	0.013	0.024	0.03	1.54
9/26/75	1300.	0.324	0.016	0.308	0.11	1.55
9/26/75	1900.	0.052	0.020	0.032	0.14	1.68
9/27/75	100.	0.061	0.022	0.039	0.21	1.80
9/27/75	700.	0.051	0.023	0.028	0.24	1.93

Date Mo/day/yr	Time Hour, min.	TN	O-P	TP	SiO_2	Na
7/ 8/75	1300.	1.87	0.439	0.647	9.9	278.70
7/ 8/75	1900.	1.94	0.508	0.621	9.7	282.10
7/ 9/75	100.	1.67	0.307	0.392	8.9	221.10
7/ 9/75	700.	1.76	0.243	0.297	8.4	214.30
7/ 9/75	1300.	1.88	0.407	0.315	8.2	190.50
7/ 9/75	1900.	1.79	0.289	0.339	8.1	238.00
7/10/75	100.	1.79	0.307	0.350	8.5	229.50
7/10/75	700.	1.39	0.408	0.415	8.7	238.00
7/10/75	1300.	1.28	0.396	0.435	8.9	239.70
7/10/75	1900.	1.22	0.347	0.369	9.1	253.30
7/11/75	100.	1.61	0.289	0.307	9.8	224.50
7/11/75	700.	1.76	0.302	0.323	9.4	275.30
7/31/75	1300.	1.58	0.271	0.305	9.2	148.53
7/31/75	1900.	1.63	0.263	0.311	9.2	150.80
8/ 1/75	100.	1.62	0.270	0.313	9.2	150.57
8/ 1/75	700.	1.62	0.266	0.315	9.3	151.25
8/ 1/75	1300.	1.77	0.252	0.297	9.3	141.06
8/ 1/75	1900.	1.58	0.223	0.267	9.0	157.14
8/ 2/75	100.	1.57	0.226	0.269	8.9	172.78
8/ 2/75	700.	1.59	0.247	0.304	8.9	177.46
8/ 2/75	1300.	1.53	0.241	0.287	9.3	170.91
8/ 2/75	1900.	1.65	0.226	0.267	8.8	184.95
8/ 3/75	100.	1.64	0.243	0.281	8.9	189.16
8/ 3/75	700.	1.66	0.251	0.298	8.9	183.54
8/19/75	1300.	1.60	0.344	0.438	9.4	184.44
8/19/75	1900.	1.45	0.346	0.428	8.8	183.37
8/20/75	100.	1.38	0.345	0.420	8.4	184.44
8/20/75	700.	1.46	0.350	0.429	8.9	202.72
8/20/75	1300.	1.71	0.353	0.437	9.2	232.84
8/20/75	1900.	1.36	0.350	0.437	8.8	223.16
8/21/75	100.	1.40	0.408	0.492	8.1	198.42
8/21/75	700.	1.43	0.363	0.445	7.7	184.44
8/21/75	1300.	1.49	0.311	0.389	7.3	174.76
9/24/75	1300.	1.51	0.480	0.565	8.9	41.01
9/24/75	1900.	1.52	0.447	0.518	8.3	42.64
9/25/75	100.	1.45	0.353	0.400	8.4	76.51
9/25/75	700.	1.54	0.380	0.464	8.8	91.56
9/25/75	1300.	1.51	0.431	0.522	9.7	102.03
9/25/75	1900.	1.68	0.434	0.524	9.3	93.04
9/26/75	100.	1.55	0.510	0.636	9.2	84.36
9/26/75	700.	1.58	0.525	0.601	9.0	81.58
9/26/75	1300.	1.87	0.519	0.623	9.5	58.19
9/26/75	1900.	1.73	0.648	0.748	9.8	50.01
9/27/75	100.	1.86	0.782	0.866	9.8	52.95
9/27/75	700.	1.98	0.823	0.905	9.8	55.00

Date Mo/day/yr	Time Hour, min.	K	Cl	Alkalinity
7/ 8/75	1300.	8.49	562.9	
7/ 8/75	1900.	8.38	572.6	
7/ 9/75	100.	6.58	485.2	
7/ 9/75	700.	6.80	480.4	
7/ 9/75	1300.	7.03	425.1	
7/ 9/75	1900.	7.82	500.4	
7/10/75	100.	7.82	528.5	
7/10/75	700.	7.59	518.9	
7/10/75	1300.	8.49	561.3	
7/10/75	1900.	8.04	571.8	
7/11/75	100.	7.93	546.1	
7/11/75	700.	8.15	579.8	
7/31/75	1300.	5.73	317.4	
7/31/75	1900.	5.96	317.1	
8/ 1/75	100.	5.62	314.1	
8/ 1/75	700.	5.88	315.8	
8/ 1/75	1300.	5.77	306.6	
8/ 1/75	1900.	6.22	349.5	
8/ 2/75	100.	6.20	370.7	
8/ 2/75	700.	6.57	366.6	
8/ 2/75	1300.	6.27	365.0	
8/ 2/75	1900.	6.74	374.0	
8/ 3/75	100.	6.85	37.8	< 4.9
8/ 3/75	700.	6.89	37.3	< 4.9
8/19/75	1300.	7.56	348.4	63.0
8/19/75	1900.	7.02	356.5	70.5
8/20/75	100.	7.24	354.1	68.5
8/20/75	700.	7.56	388.5	70.0
8/20/75	1300.	8.21	430.1	82.5
8/20/75	1900.	8.42	419.7	85.0
8/21/75	100.	7.88	380.5	76.5
8/21/75	700.	6.59	360.5	69.5
8/21/75	1300.	6.37	347.6	63.0
9/24/75	1300.	3.83	73.9	
9/24/75	1900.	3.81	81.1	
9/25/75	100.	4.56	150.7	
9/25/75	700.	5.33	189.6	
9/25/75	1300.	5.90	198.0	
9/25/75	1900.	5.76	190.2	
9/26/75	100.	6.73	176.2	
9/26/75	700.	7.08	178.8	
9/26/75	1300.	6.09	109.1	
9/26/75	1900.	6.69	95.7	
9/27/75	100.	7.35	100.7	
9/27/75	700.	7.63	121.7	

APPENDIX B. LABORATORY RESULTS FOR SAMPLING DATES

3. Otter Creek

Date Mo/day/yr	Time Hour, min.	NO_x	NO_2	NO_3	NH_4	TKN
7/ 8/75	1300.	0.026	0.009	0.017	5.13	10.60
7/ 8/75	1900.	0.188	0.016	0.172	3.67	7.59
7/ 9/75	100.	0.023	0.018	0.005	3.29	6.21
7/ 9/75	700.	0.034	0.024	0.010	3.53	8.19
7/ 9/75	1300.	0.028	0.012	0.016	2.41	7.09
7/ 9/75	1900.	0.058	0.009	0.049	2.41	6.19
7/10/75	100.	0.096	0.015	0.081	2.37	5.78
7/10/75	700.	0.073	0.024	0.049	2.16	6.04
7/10/75	1300.	0.016	0.010	0.006	2.58	8.53
7/10/75	1900.	0.107	0.016	0.091	2.92	6.07
7/11/75	100.	0.021	0.012	0.009	2.16	5.48
7/11/75	700.	0.036	0.010	0.026	1.91	6.36
7/31/75	1300.	0.015	0.015	< 0.004	3.79	7.03
7/31/75	1900.	0.012	0.010	< 0.004	6.39	11.18
8/ 1/75	100.	0.409	0.013	0.396	5.34	9.42
8/ 1/75	700.	0.061	0.012	0.049	4.07	6.48
8/ 1/75	1300.	0.487	0.244	0.243	4.50	6.85
8/ 1/75	1900.	0.117	0.050	0.067	4.72	8.64
8/ 2/75	100.	0.142	0.071	0.071	4.48	7.43
8/ 2/75	700.	0.096	0.065	0.031	4.32	6.37
8/ 2/75	1300.	0.022	0.018	< 0.004	5.90	10.57
8/ 2/75	1900.	0.031	0.016	0.015	5.07	8.00
8/ 3/75	100.	0.036	0.012	0.024	4.75	7.12
8/ 3/75	700.	0.023	0.018	0.005	4.34	6.31
8/19/75	1300.	0.900	0.722	0.178	3.54	5.41
8/19/75	1900.	0.716	0.349	0.367	4.37	7.45
8/20/75	100.	3.436	1.560	1.876	2.71	4.79
8/20/75	700.	2.277	1.549	0.728	2.69	4.85
8/20/75	1300.	0.948	0.599	0.349	2.32	4.60
8/20/75	1900.	0.755	0.487	0.268	2.27	4.93
8/21/75	100.	0.668	0.439	0.229	2.33	4.38
8/21/75	700.	0.610	0.410	0.200	2.40	4.39
8/21/75	1300.	0.528	0.347	0.181	2.43	5.00
8/21/75	1900.	0.352	0.252	0.100	2.75	5.28
8/22/75	100.	0.330	0.207	0.123	2.59	5.25
8/22/75	700.	0.507	0.274	0.233	2.59	4.97
9/24/75	1300.	0.203	0.097	0.106	6.00	7.22
9/24/75	1900.	0.290	0.111	0.179	5.49	8.09
9/25/75	100.	0.352	0.143	0.209	4.79	7.22
9/25/75	700.	0.220	0.062	0.158	4.88	7.78
9/25/75	1300.	0.279	0.034	0.245	4.38	7.72
9/25/75	1900.	0.690	0.043	0.647	4.63	7.36
9/26/75	100.	0.403	0.050	0.353	3.27	5.69
9/26/75	700.	0.284	0.050	0.234	2.55	5.04
9/26/75	1300.	2.052	1.209	0.843	1.10	2.36
9/26/75	1900.	1.425	0.898	0.527	1.20	2.56
9/27/75	100.	0.706	0.386	0.320	2.66	5.00
9/27/75	700.	0.452	0.201	0.251	3.18	6.25

APPENDIX B-3. (CONTINUED)

Date Mo/Day/Yr	Time Hour, Min.	TN	O-P	TP	SiO_2	Na
7/ 8/75	1300.	10.63	2.282	3.863	11.2	51.90
7/ 8/75	1900.	7.78	2.471	3.644	9.9	41.70
7/ 9/75	100.	6.23	2.075	3.695	9.4	38.70
7/ 9/75	700.	8.22	2.075	3.726	9.4	39.10
7/ 9/75	1300.	7.12	1.475	2.857	9.0	98.00
7/ 9/75	1900.	6.25	1.530	2.989	8.7	100.10
7/10/75	100.	5.88	1.389	3.213	8.2	78.70
7/10/75	700.	6.11	1.344	2.537	8.6	89.80
7/10/75	1300.	8.55	1.480	3.604	8.9	100.10
7/10/75	1900.	6.18	1.337	2.699	8.6	87.70
7/11/75	100.	5.50	1.471	2.989	8.7	75.40
7/11/75	700.	6.40	1.475	2.791	9.0	63.40
7/31/75	1300.	7.05	2.234	2.485	10.1	26.71
7/31/75	1900.	11.19	2.288	2.762	10.6	29.43
8/ 1/75	100.	9.83	1.995	2.475	10.5	26.48
8/ 1/75	700.	6.54	1.836	2.152	10.5	25.13
8/ 1/75	1300.	7.34	2.400	2.298	11.2	26.48
8/ 1/75	1900.	8.76	2.024	2.227	10.8	26.03
8/ 2/75	100.	7.57	1.809	2.013	10.9	25.13
8/ 2/75	700.	6.47	1.973	2.152	10.6	24.22
8/ 2/75	1300.	10.59	2.542	2.545	10.7	25.13
8/ 2/75	1900.	8.03	1.926	2.131	10.5	24.67
8/ 3/75	100.	7.16	2.290	2.243	10.7	24.67
8/ 3/75	700.	6.33	1.946	2.131	10.6	22.63
8/19/75	1300.	6.31	2.168	2.711	10.7	35.26
8/19/75	1900.	8.17	3.242	3.906	10.6	30.25
8/20/75	100.	8.23	2.298	2.768	11.1	34.28
8/20/75	700.	7.13	2.348	2.815	9.8	42.44
8/20/75	1300.	5.55	2.148	2.538	9.9	32.21
8/20/75	1900.	5.69	2.103	2.491	9.8	30.69
8/21/75	100.	5.05	2.123	2.538	11.1	30.69
8/21/75	700.	5.00	2.093	2.523	11.7	28.08
8/21/75	1300.	5.53	2.263	2.653	11.3	27.31
8/21/75	1900.	5.63	2.278	2.794	9.9	26.44
8/22/75	100.	5.58	2.233	2.575	10.0	24.38
8/22/75	700.	5.48	2.258	2.685	10.0	24.59
9/24/75	1300.	7.42	2.786	3.831	9.9	46.41
9/24/75	1900.	8.38	3.093	3.806	10.5	41.17
9/25/75	100.	7.57	3.268	3.769	10.7	41.34
9/25/75	700.	8.00	3.082	4.167	10.9	43.13
9/25/75	1300.	8.00	2.907	6.213	10.0	43.13
9/25/75	1900.	8.05	2.469	4.514	8.7	26.61
9/26/75	100.	6.09	2.211	3.396	7.8	28.57
9/26/75	700.	5.32	1.981	2.853	7.3	25.79
9/26/75	1300.	4.41	1.910	2.532	7.6	25.96
9/26/75	1900.	3.99	1.806	2.195	7.9	25.14
9/27/75	100.	5.71	2.277	2.640	9.1	25.47
9/27/75	700.	6.70	2.551	3.225	9.9	27.10

APPENDIX B-3. (CONTINUED)

Date Mo/day/yr	Time Hour, min.	K	Cl	Alkalinity
7/ 8/75	1300.	14.40	81.2	
7/ 8/75	1900.	11.35	80.8	
7/ 9/75	100.	14.81	78.8	
7/ 9/75	700.	15.10	77.8	
7/ 9/75	1300.	14.10	197.8	
7/ 9/75	1900.	13.97	203.9	
7/10/75	100.	12.82	160.4	
7/10/75	700.	13.36	200.6	
7/10/75	1300.	14.73	200.8	
7/10/75	1900.	13.56	180.4	
7/11/75	100.	12.89	152.2	
7/11/75	700.	11.59	132.1	
7/31/75	1300.	13.30	41.9	
7/31/75	1900.	14.21	41.1	
8/ 1/75	100.	14.56	43.9	
8/ 1/75	700.	12.69	41.5	
8/ 1/75	1300.	13.71	42.2	
8/ 1/75	1900.	14.71	41.2	
8/ 2/75	100.	13.21	40.5	
8/ 2/75	700.	12.91	40.2	
8/ 2/75	1300.	15.03	41.2	
8/ 2/75	1900.	14.49	40.6	
8/ 3/75	100.	14.60	41.1	
8/ 3/75	700.	13.93	39.8	
8/19/75	1300.	16.89	70.1	72.0
8/19/75	1900.	29.01	59.5	70.0
8/20/75	100.	20.44	64.9	65.5
8/20/75	700.	17.71	80.1	74.0
8/20/75	1300.	14.03	59.3	63.0
8/20/75	1900.	13.30	56.7	
8/21/75	100.	12.91	58.3	
8/21/75	700.	12.91	52.9	
8/21/75	1300.	14.16	51.9	
8/21/75	1900.	14.44	47.9	
8/22/75	100.	13.73	44.9	
8/22/75	700.	13.89	44.1	
9/24/75	1300.	16.25	74.7	
9/24/75	1900.	15.61	73.7	
9/25/75	100.	16.14	73.1	
9/25/75	700.	17.01	75.7	
9/25/75	1300.	16.97	64.7	
9/25/75	1900.	13.06	45.7	
9/26/75	100.	12.55	53.7	
9/26/75	700.	10.47	47.1	
9/26/75	1300.	9.94	49.7	
9/26/75	1900.	9.17	51.1	
9/27/75	100.	11.89	50.7	
9/27/75	700.	13.78	51.7	

APPENDIX B. LABORATORY RESULTS FOR SAMPLING DATES

4. N.W. Taylor Creek

Date Mo/Day/Yr	Time Hour, Min.	NO_x	NO_2	NO_3	NH_4	TKN
7/ 8/75	1300.	0.018	0.007	0.011	0.06	1.33
7/ 8/75	1900.	0.010	0.006	< 0.004	0.03	1.38
7/ 9/75	100.	0.010	0.006	0.004	0.03	1.33
7/ 9/75	700.	0.010	0.006	< 0.004	0.04	1.37
7/ 9/75	1300.	0.025	0.008	0.017	0.06	1.62
7/ 9/75	1900.	0.012	0.008	< 0.004	0.06	1.98
7/10/75	100.	0.128	0.011	0.117	0.05	1.63
7/10/75	700.	0.064	0.011	0.053	0.10	1.81
7/10/75	1300.	0.073	0.012	0.061	0.09	1.86
7/10/75	1900.	0.032	0.011	0.021	0.09	1.87
7/11/75	100.	0.086	0.011	0.075	0.10	1.88
7/11/75	700.	0.032	0.011	0.021	0.11	1.93
7/31/75	1300.	0.145	0.019	0.126	0.03	1.96
7/31/75	1900.	0.143	0.019	0.124	0.02	2.01
8/ 1/75	100.	0.135	0.019	0.116	0.03	2.06
8/ 1/75	700.	0.141	0.018	0.123	0.06	2.09
8/ 1/75	1300.	0.131	0.018	0.113	0.01	2.08
8/ 1/75	1900.	0.142	0.019	0.123	0.04	2.14
8/ 2/75	100.	0.175	0.021	0.154	0.03	2.06
8/ 2/75	700.	0.162	0.021	0.141	0.05	2.17
8/ 2/75	1300.	0.197	0.020	0.177	< 0.01	2.09
8/ 2/75	1900.	0.170	0.012	0.158	< 0.01	2.01
8/ 3/75	100.	0.397	0.017	0.380	0.02	2.08
8/ 3/75	700.	0.195	0.019	0.176	0.02	2.16
8/19/75	1200.	0.123	0.016	0.107	0.10	2.75
8/20/75	1200.	0.128	0.013	0.115	0.12	1.91
8/22/75	1200.	0.123	0.016	0.107	0.11	2.14
9/24/75	1300.	0.020	0.009	0.011	0.07	1.57
9/24/75	1900.	0.023	0.010	0.013	0.03	1.58
9/25/75	100.	0.023	0.010	0.013	0.02	1.56
9/25/75	700.	0.034	0.010	0.024	< 0.01	1.61
9/25/75	1300.	0.019	0.011	0.008	0.02	1.57
9/25/75	1900.	0.080	0.009	0.071	0.01	1.52
9/26/75	100.	0.032	0.008	0.024	0.01	1.58
9/26/75	700.	0.021	0.009	0.012	0.02	1.64
9/26/75	1300.	0.027	< 0.004	0.023	0.04	1.63
9/26/75	1900.	0.018	< 0.004	0.014	0.02	1.50
9/27/75	100.	0.027	0.015	0.012	0.02	1.51
9/27/75	700.	0.024	0.014	0.010	0.03	1.54

APPENDIX B-4 (CONTINUED)

Date Mo/day/yr	Time Hour, min.	TN	O-P	TP	SiO_2	Na
7/ 8/75	1300.	1.35	0.195		5.1	13.60
7/ 8/75	1900.	1.39	0.190		4.9	15.20
7/ 9/75	100.	1.34	0.191		4.7	15.60
7/ 9/75	700.	1.38	0.208		5.0	14.80
7/ 9/75	1300.	1.65	0.160		6.4	13.30
7/ 9/75	1900.	1.99	0.151		5.2	13.10
7/10/75	100.	1.76	0.157		5.9	12.70
7/10/75	700.	1.87	0.138		5.5	13.60
7/10/75	1300.	1.93	0.165		7.1	15.60
7/10/75	1900.	1.90	0.173		6.9	15.20
7/11/75	100.	1.97	0.166		7.1	14.40
7/11/75	700.	1.96	0.166		6.8	13.60
7/31/75	1300.	2.11	0.446	0.582	7.3	11.09
7/31/75	1900.	2.15	0.436	0.562	7.3	14.71
8/ 1/75	100.	2.20	0.434	0.557	7.3	13.80
8/ 1/75	700.	2.23	0.456	0.557	7.3	14.94
8/ 1/75	1300.	2.21	0.411	0.532	9.2	11.99
8/ 1/75	1900.	2.28	0.407	0.512	7.3	15.39
8/ 2/75	100.	2.24	0.446	0.542	9.2	12.22
8/ 2/75	700.	2.33	0.469	0.582	9.4	11.99
8/ 2/75	1300.	2.29	0.488	0.577	7.4	13.35
8/ 2/75	1900.	2.18	0.432	0.582	9.7	12.45
8/ 3/75	100.	2.48	0.475	0.607	9.6	11.54
8/ 3/75	700.	2.36	0.476	0.618	7.2	14.71
8/19/75	1200.	2.87	0.644	0.957	7.1	9.69
8/20/75	1200.	2.04	0.311	0.442	4.6	8.60
8/22/75	1200.	2.26	0.424	0.596	6.0	10.67
9/24/75	1300.	1.59	0.176	0.271	6.1	7.63
9/24/75	1900.	1.60	0.198	0.320	6.1	7.14
9/25/75	100.	1.58	0.213	0.333	4.9	11.07
9/25/75	700.	1.64	0.188	0.335	4.6	6.32
9/25/75	1300.	1.59	0.160	0.301	6.0	7.47
9/25/75	1900.	1.60	0.165	0.276	6.2	8.45
9/26/75	100.	1.61	0.167	0.238	4.8	10.90
9/26/75	700.	1.66	0.161	0.247	4.8	6.32
9/26/75	1300.	1.66	0.138	0.279	5.1	7.14
9/26/75	1900.	1.52	0.142	0.251	5.0	5.83
9/27/75	100.	1.54	0.167	0.283	5.0	12.05
9/27/75	700.	1.56	0.187	0.301	5.1	8.94

APPENDIX B-4 (CONTINUED)

Date Mo/Da/Yr.	Time Hour, Min.	K	Cl
7/ 8/75	1300.	2.93	30.1
7/ 8/75	1900.	2.31	23.1
7/ 9/75	100.	2.48	22.5
7/ 9/75	700.	2.34	24.1
7/ 9/75	1300.	4.08	23.7
7/ 9/75	1900.	2.37	21.1
7/10/75	100.	2.37	22.1
7/10/75	700.	2.34	22.5
7/10/75	1300.	2.87	25.5
7/10/75	1900.	2.89	28.5
7/11/75	100.	2.93	27.1
7/11/75	700.	2.91	27.9
7/31/75	1300.	2.98	24.3
7/31/75	1900.	2.26	23.4
8/ 1/75	100.	2.44	23.1
8/ 1/75	700.	2.91	20.8
8/ 1/75	1300.	3.24	21.3
8/ 1/75	1900.	2.89	24.5
8/ 2/75	100.	3.24	23.5
8/ 2/75	700.	3.35	21.2
8/ 2/75	1300.	2.91	23.1
8/ 2/75	1900.	3.02	21.4
8/ 3/75	100.	3.13	21.1
8/ 3/75	700.	2.63	22.1
8/19/75	1200.	3.66	20.3
8/20/75	1200.	2.77	25.9
8/22/75	1200.	3.14	19.5
9/24/75	1300.	1.90	21.7
9/24/75	1900.	1.94	21.9
9/25/75	100.	1.83	20.9
9/25/75	700.	1.85	15.7
9/25/75	1300.	1.74	17.7
9/25/75	1900.	1.81	25.7
9/26/75	100.	1.30	63.7
9/26/75	700.	1.48	16.9
9/26/75	1300.	1.61	24.7
9/26/75	1900.	1.63	17.7
9/27/75	100.	1.46	19.7
9/27/75	700.	1.88	20.1